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II. A REVIEW OF MINE RECLAMATION ACTIVITIES IN CANADA

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MINING, LAND USE, AND THE ENVIRONMENT

II. A REVIEW OF MINE RECLAMATION ACTIVITIES IN CANADA

by

I.B. Marshall

Lands Directorate
Environment Canada

Ottawa, 1983

LAND USE IN CANADA SERIES

The ***Land Use in Canada Series*** is designed to address major land-use issues and problems in Canada. The series, produced by and for the Lands Directorate of Environment Canada, examines the causes and consequences of major land problems and land-use trends throughout Canada and the role of various government programs in eliciting solutions.

Incorporating the earlier series entitled ***Land Use Programs in Canada*** which reviewed the land-use programs of Canada's ten provinces, the series examines, from a national perspective, activities affecting the use of Canada's land.

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PREFACE

Volume One of this two part study on Mining, Land Use and the Environment examined the impact of the mining industry on the land resources of Canada. The specific purpose of the first volume was to provide a national overview of the scope of mining land use activities, including the nature and extent of land degradation processes attributable to mining, their effects on neighbouring land resources, and the potential for land use conflicts.

One of the major solutions or compromise solutions to land use conflicts associated with land degradation processes has been the use of reclamation techniques. Today, reclamation is considered an essential aspect of resource management, to the extent that it has been incorporated in one form or another into regulations and policies in all the provinces. If reclamation is to be a viable answer to land degradation problems and a means of alleviating land resource conflicts, then it is essential that more is known about reclamation activities in Canada.

The purpose of Volume Two of this study is to provide a general overview of the progress that has been made in the field of reclamation activities. The study reviews the effects of reclamation legislation and policies now in force, as well as programs now being conducted by the various levels of government, industry and universities, to find satisfactory solutions to environmental problems, and identify the major problems still limiting the successful reclamation and re-use of land resources affected by mining activities.

The Lands Directorate of Environment Canada is engaged in a continuing program of research into the causes and consequences of land problems and issues in Canada and the means by which they can be resolved. Through a better understanding of the demands for land, measures can be designed to influence its uses so that all Canadians will benefit from the wise use of their land resource.

R.J. McCormack
Director General
Lands Directorate

ACKNOWLEDGEMENTS

A national study of this nature is impossible without the assistance and cooperation of both Federal and Provincial government departments across Canada. Advice and information provided by all such agencies especially the various services within Environment Canada are gratefully acknowledged. Special thanks to Bill Blakeman, of the Environmental Protection Service for his critical review and counsel received during the course of the study. In addition, the author is indebted to John MacLatchy of the Environmental Protection Service and Dr. Paul Ziemkiewicz, Chairman of the Alberta Reclamation Research Technical Advisory Committee for their critical review of regulatory and program aspects of the report. Also thanks to Ilze Reiss for her patience in preparing the final manuscript for editing. J. Phillip Nicholson Consultants Inc. were responsible for editing, manuscript preparation, design and layout of the report. Finally, special thanks to Lucille Chénard for her perserverance in providing the typing services.

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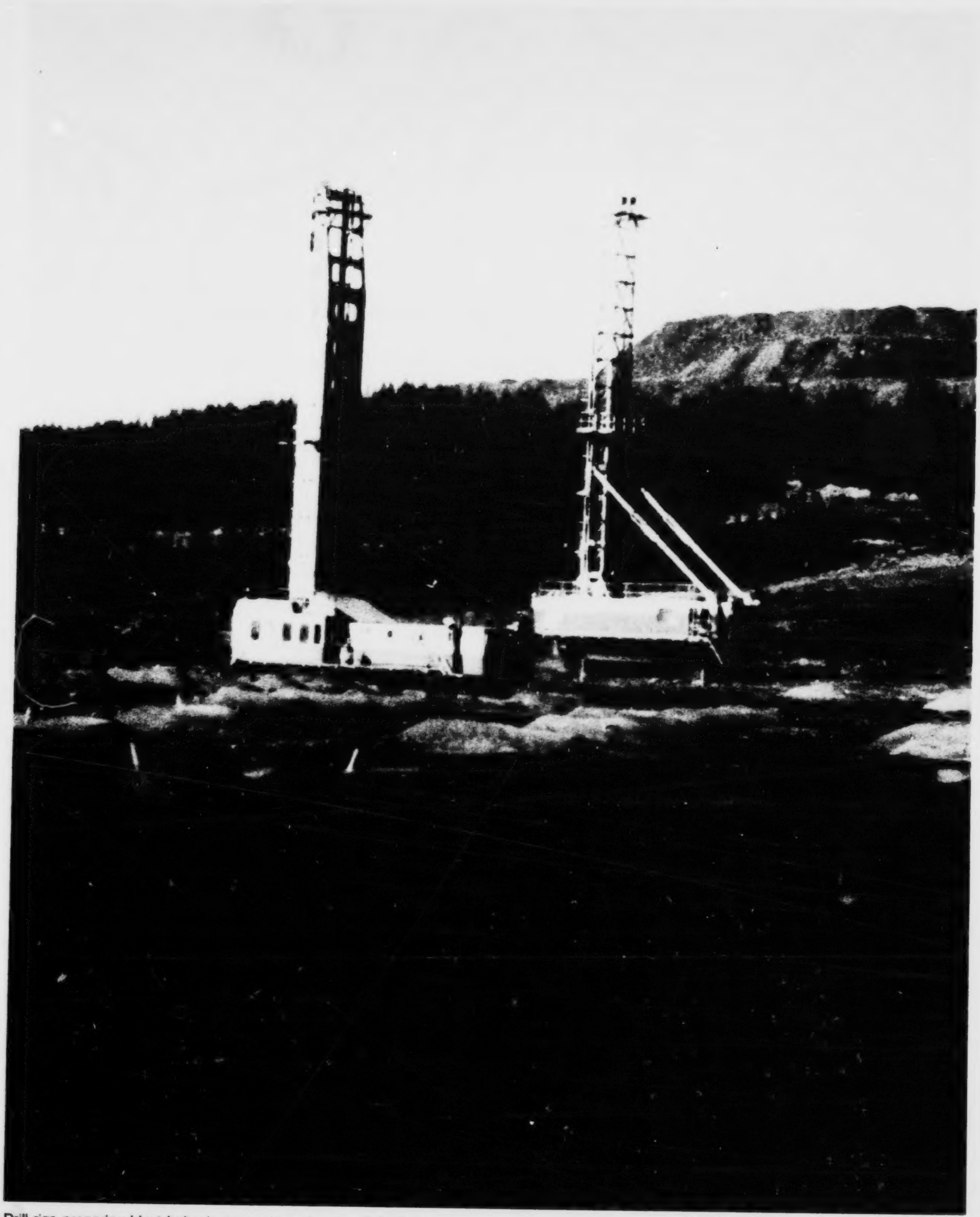


Drill rigs preparing blast holes in open-pit coal seam, B.C. Coal Ltd., Sparwood, British Columbia
I.B. Marshall, Environment Canada

Chapter One

INTRODUCTION

The first volume of this two part study on Mining, Land Use and the Environment examined the impact of the mining industry on the land resources of Canada. The specific purpose of the first volume was to provide a national overview of the scope of mining land use activities, including the nature and extent of land degradation processes attributable to mining, their effects on neighbouring land resources, and the potential for land use conflicts.

One of the major solutions or compromise solutions to land use conflicts and land degradation processes has been the use of reclamation techniques. Many of these techniques have, at the same time, proved useful in reducing the impact of problems arising from air and waterborne pollutants. Today, reclamation is considered an essential aspect of resource management, to the extent that it has been incorporated in one form or another into regulations and policies in all the provinces. As a result, the approval of many controversial mineral and energy developments has been contingent upon the proponent accepting the responsibility of reclaiming disturbed land to a pre-determined land use. Dependence upon this solution has certain drawbacks. Reclamation experience in Canada is relatively recent, fragmented and often of a short-term nature. Indeed, the new regulatory requirements were the major catalyst in initiating the rapid expansion of reclamation activities in the past decade. At the national level, however, very little attention has been paid to the efforts and progress made in the field of reclamation, both within and outside the mining industry, to reduce the impact of mining activities and cleanup the existing backlog of disturbed lands. If reclamation is to be a viable answer to land degradation problems and a means of alleviating land resource conflicts, then it is essential that more is known about reclamation activities in Canada.

NATURE AND EXTENT OF THE PROBLEM

In Volume I, the total land area disturbed, utilized and alienated by mining activities was estimated to be 284,327 hectares, equivalent to approximately half the size of Prince Edward Island (Marshall, 1982). Of this total, thirty-three percent of the disturbance occurred in Ontario, twenty percent in Quebec, and fifteen percent in British Columbia. In terms of impact, the areas affected by "mine wastes" (233,968 hectares) have the greatest degree of physical and chemical alteration. Land utilized for various support and operational "facilities", while having fewer problems of chemical alteration nevertheless require considerable work to cleanup the physical alteration of the land surface (Figure 1).

The estimated land area disturbed, utilized, and alienated by the metallic and non-metallic mineral sectors (excluding construction materials) is 112,289 hectares. Smelter and refinery operations located in industrial sites within urban centres utilized an additional 7,670 hectares. At the present forecast rate of mine development, minimum estimates indicate an increase in land requirements for this sector of approximately 60,000 hectares over a twenty-year period, ending in 2000 AD (Marshall, 1982).

The minimum area disturbed and alienated from other use by the extraction of non-metallic construction materials is estimated at 138,025 hectares. This figure represents thousands of individual pits and quarries, the majority of which can be found within an eight-kilometre radius of most populated centres. Based on production rates prevalent in the 1960s and early 1970s Marshall (1982), estimated that 215,231 hectares of additional land will be required to meet demands for construction aggregates (sand, gravel, and crushed stone) in the period 1980 to 2000. But, in light of the continued decline in construction in recent years, actual land requirements are likely to be only one-half to two-thirds of this figure.

The energy-related sector of mining has affected a further 34,013 hectares of land. A projected three-fold increase in surface-mined coal over the next twenty years in Canada will result in an additional land disturbance of between 18,000 to 20,000 hectares. In addi-

Hudson Bay Mining and Smelting underground gold and silver mine, Osborne Lake, Manitoba
NFB — Photothèque — ONF, Bryce Flynn

tion the expansion of oil sands operations in the immediate future (pre-1990) which will be confined to the potential new ALSANDS plant, will disturb at least 8,900 additional hectares. The maximum potential area affected by all existing and proposed oil sands sites is estimated at approximately 30,000 hectares, including facilities, wastes, and alienated lands.

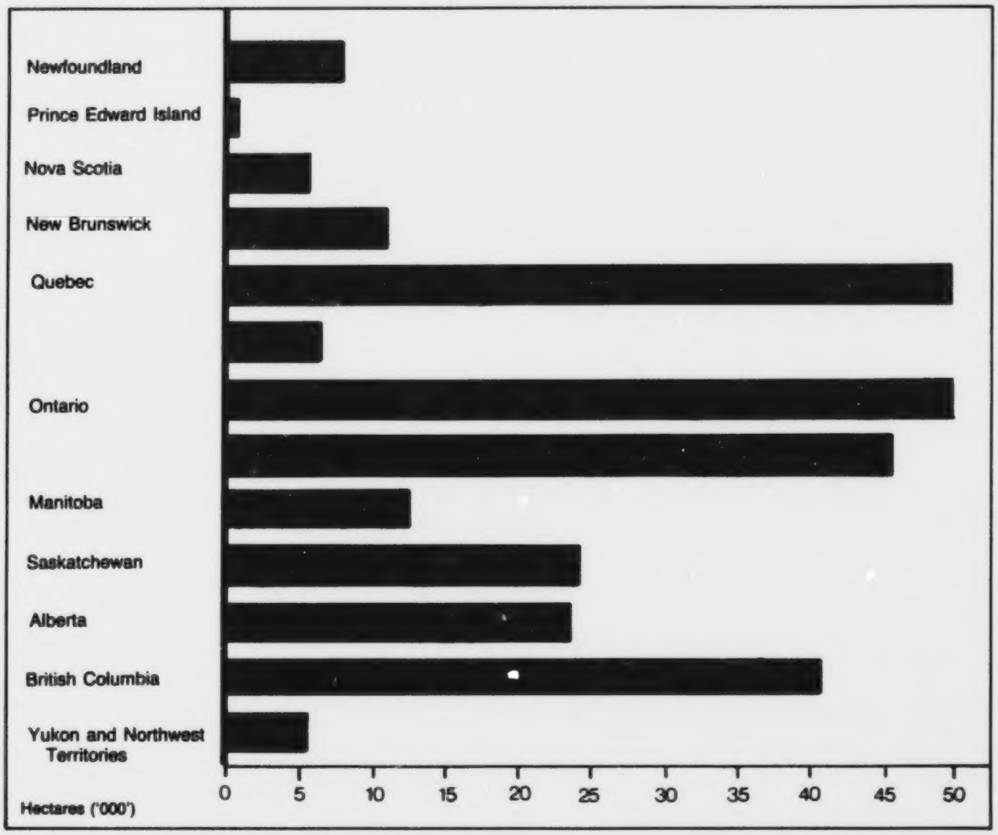
The estimates on the future rate of mine disturbances are based on economic conditions at the start of the 1980s. The current world-wide recession, however, has severely reduced the demand for construction aggregates, base metals and oil from oil sands, decreasing significantly the rate of mine development in Canada.

In addition to direct disturbances, mining can also have a considerable influence on the land surrounding its operations, and this influence, referred to as the "shadow effect", may indeterminantly affect an area many times greater than the actual mine site (or lands within its operational control). Often these shadow effects have neither a visible nor an immediate impact, taking several years to reveal themselves. Infrastructure requirements (railways, roads, power lines and plants, water storage etc.) can further extend the land area directly influenced by mine-related activities.

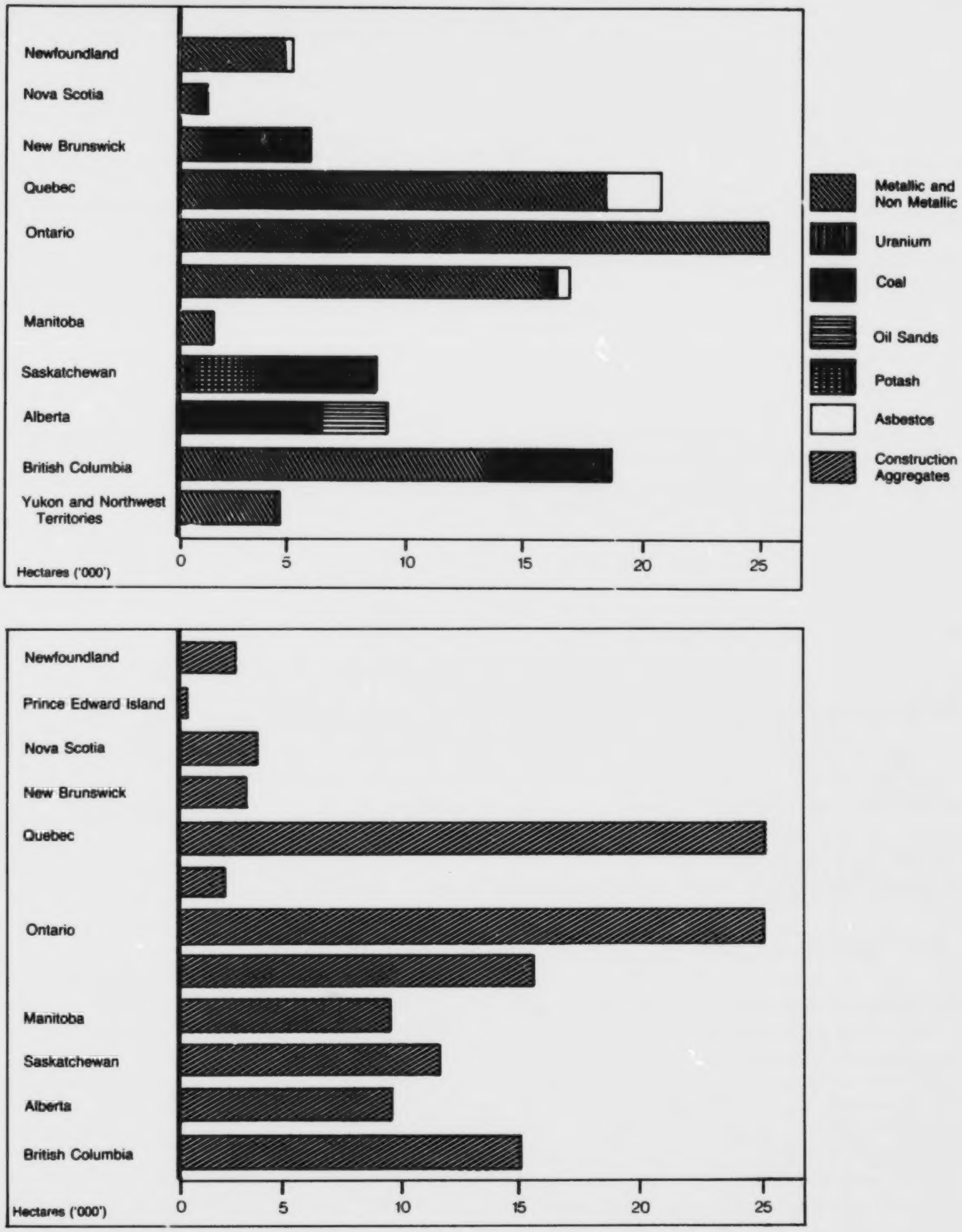
FIGURE 1. LAND AREA DISTURBED, UTILIZED AND ALIENATED BY MINING

A. ALL MINING ACTIVITIES

Includes land area disturbed by mine wastes and facilities and those land areas alienated from alternate use due to their classification by a company as maintaining future reserves and their proximity to, or encirclement by, mine wastes or fixed facilities.



B. LAND AREA DISTURBED BY MINING WASTES*



*Mining Wastes are defined in this study to include all lands affected by open pits, strip mines, underground shaft sites, tailings, waste rock, overburden dumps, slag, and settling ponds.

Source: Marshall, 1982

LAND RECLAMATION DEFINED

Frequently the terms "reclamation", "rehabilitation", "restoration", and "re-vegetation" have been used synonymously to describe cleanup and improvement work done on disturbed lands. "Reclamation" has been interpreted in this study as including any process that promotes soil conservation and the productive use of degraded or disturbed land. Reclamation implies that the site is made habitable to organisms that were originally inhabitants of the area (National Academy of Sciences, 1974), and includes any treatment which is not restoration.

"Restoration" is defined as recreating the original topography and re-establishing the previous land use (Down and Stocks, 1977).

"Rehabilitation" implies that the land will be returned to a form and a level of productivity that conforms with a prior land use plan, which includes provision for a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values.

Generally there are only three options for the actual management or reclamation of mined lands (Cairns, 1979):

(i) ***To do nothing and leave the land as it was when the mining was completed.*** This option has become socially and economically unacceptable; and some form of reclamation is now required in all provinces and territories. In many instances, disturbed lands can be rehabilitated to provide a base for various renewable resources. More importantly, the potential offsite impacts of abandoned mine lands may result in long-term degradation of neighbouring land and water resources.

(ii) ***To restore it to its original condition.*** Restoration as a viable second option is almost impossible to achieve, for both technical and economic reasons. It also limits the option of an alternative land use that may be preferable to the original use. Full restoration to an original condition, given current knowledge and experience, may even be possible, but it may take decades to achieve the same level of productivity. The drawback of this option lies in the difficulty of achieving political and economic support for such long-range benefits, when immediate results have become the norm of society.

(iii) ***To reclaim it to an ecologically improved and more socially acceptable condition.*** It is not surprising that this has become the most widely accepted option in Canada.

It embraces elements of both reclamation and rehabilitation. It is often difficult, however, to separate the two, since most statutes and regulations in Canada use the term "reclamation", but frequently define it as though it were, in fact, "rehabilitation". Reclamation may include any or all of a number of procedures including landscaping, soil amelioration, revegetation, and chemical/physical stabilization. Demands for "full restoration" are required under certain circumstances, notably with regard to former agricultural lands.

Option one may be acceptable when the site resembles former abandoned mines in similar ecological conditions that have recovered under natural conditions or with only limited assistance. This assistance may be in the form of a cover crop or a physical/chemical sealant which prevents erosion while native species, capable of living under the new conditions, establish themselves. This may be the ideal situation for remote, isolated sites that present no environmental hazard or requirement for aesthetic upgrading.

Today most reclamation programs are implemented for the following reasons (Falkie and Saperstein, 1971):

(i) ***Potential for Multiple Use:*** To avoid the loss of surface value intrinsic to the land.

(ii) ***Avoid Public Displeasure:*** To make the mine site as palatable as possible to neighbours. Reducing the extent of impacts, coupled with good reclamation and conservation techniques are important factors in reducing opposition to mining developments.

(iii) ***Aesthetics and Work Conditions:*** To improve the perceived aesthetic quality and enhance the safety of working conditions on the site for employees.

(iv) ***Engineering and Pollution Control:*** To stabilize dangerous slopes, reduce erosion, sedimentation, air and water pollution, etc.

Research and operational experience have shown the value of preplanning orderly production and progressive rehabilitation Bauer (1970), Thirgood (1970, 1972), Murray (1977), Hewitt and Vos (1970), and Coates (1971, 1974, 1975).[1]

---

[1] Preplanned progressive reclamation schemes have proved to be most effective in surface mining operations involving coal, sand and gravel.

The major advantages of this approach have been extracted from the works of the authors cited above and are presented below:

1. It improves the appearance of a site, both during and after the operations.
2. It allows for an optimal use of equipment which might otherwise remain idle, costing an operator non-productive capital expenditures.
3. It avoids costly rehandling of materials by carrying out sloping and grading during the course of the extracting operations.
4. It allows for selective materials handling and storage.
5. It makes use of overburden or other wastes for fill (depending on chemical composition or other limiting physical characteristics).
6. It is paid for with today's dollars.
7. It allows for early return of capital tied up in bonds or security deposits.
8. It allows for the early establishment of field research programs to deal with reclamation problems that would not normally have been identified if left to the end of mining operations.
9. It can result in the creation of useable and more valuable land areas.

Although an operator who adopts the concepts of planned progressive rehabilitation incurs higher initial operating costs, these costs often may be recovered from the sale of the rehabilitated land, which is commonly suitable for "higher" use particularly in the case of the aggregate industry. Reclamation costs, however, may often exceed the market value of land, particularly when the land is in a remote location.

PURPOSE OF THE STUDY

The general purpose of Part Two of this study on Mining, Land Use and the Environment is to provide a general overview of the progress that has been made in the field of reclamation to reduce the effects of land disturbance in the past decade. It attempts to review the effects of reclamation legislation and policies now in force, as well as programs now being conducted by the various levels of government, industry and universities, to find satisfactory solutions to environmental problems, and identify the major problems still limiting the successful reclamation and re-use of land resources affected by mining activities.

It should be stressed that the study concentrates on the "land" aspects of environmental degradation by mining activities. The interface with the air and water resource components is reviewed only when it is necessary to place reclamation requirements in proper perspective.

The specific aims of this study have been to:

1. Identify and summarize the regulatory requirements for reclamation in Canada.
2. Outline the achievements and assess the effectiveness of the current legislation aimed at increasing land reclamation and rehabilitation.
3. Inquire into the factors affecting reclamation costs.
4. Survey and review research programs assumed or undertaken by Federal and Provincial agencies, universities and industry in the field of land reclamation.
5. Review progress in research and operational reclamation programs, recent trends and developments, and identify problem areas requiring further investigation and research.

APPROACH

An attempt has been made to provide a general overview of the direction, type and amount of involvement in reclamation activities in government, industry and university sectors. There was no attempt to provide any quantitative results or original research. The study is intended to be a reconnaissance level inventory, review and general analysis of the qualitative information available. A deliberate attempt was made to restrict the study to those activities having direct application to reclamation of mining disturbances. It embraces the exploration, development, extraction, beneficiation and permanent closure stages of mining where reclamation techniques are required to overcome the effects of land degradation. It includes metallic mines, industrial mineral and construction aggregate sites, coal and uranium mines, oil sands extraction; and exploration activities related to the development of the respective resources.

This compilation of reclamation projects emphasizes federal, provincial and university involvement in the field. Although every effort was made to review all mining company projects, the study focuses primarily on those projects which were undertaken in cooperation with government or university departments and agencies. All reclamation programs conducted by members of the mining industry were included where sufficient details were available. However, some companies may have been missed due to the scope of the countrywide review, availability of information, confidentiality of reports, and overlapping activities arising out of the increased use of private consultants, university personnel and quasi-government agencies. Omissions within the various levels of governments arose out of overlap, changing jurisdiction, and funding of the various agencies and individuals involved in reclamation activities. Some omissions were the result of difficulties in separating out the growing number of individuals and agencies involved in providing ***ad hoc*** advice, administrative review, and inspection, from basic and applied research activities.

The vast number of pre-disturbance field surveys and inventories (soils, geology, biophysical, environmental impact assessment, etc.) that could be indirectly related to reclamation were excluded in order to make the study manageable. However, a number of these surveys were included in the study, when specific sections of their reports dealt with a) surface disturbances; b) the ability of native species to regenerate; or c) when the purpose of such projects included procedures or recommendations for reclamation or revegetation.

Although Environmental Impact Assessments were not included, they often helped to define the potential size and impact of future mining operations. Reclamation activities completed within the past decade were included for information purposes and to indicate the direction and rate of growth in reclamation activities. Also, many of the earlier reclamation programs continue to be monitored for success rates and potential future problems.

Due to the scope of the study and limitations of time and manpower, it was necessary to restrict much of the inventory, data collection and assessments to existing written information found in published texts, technical and professional journals, reports and other related items. Much of the information obtained in the literature was restricted to a particular area or field of inquiry, rarely treating it on a nationwide basis. Thus, it was necessary to develop data by means other than a review of literature. Several trips were made across the country to conduct interviews with federal, provincial, university and industry authorities. This included discussions at conferences and workshops, and follow-up correspondence. The assistance provided by those interviewed contributed greatly to the development of the information base for this study.

REGULATORY REQUIREMENTS FOR RECLAMATION

HISTORICAL EVOLUTION OF RECLAMATION REQUIREMENTS

Before 1960, little legislation had been enacted in Canada at either the federal or provincial levels dealing with the reclamation or rehabilitation of land disturbed by mining. There were as well virtually no controls before 1970 that could have been used to control the impact of pits and quarries on the environment. Popular concern over the effects of pollution on the natural environment increased dramatically in the Sixties, however, leading to a proliferation of legislation and control measures designed to reduce the impact of various human activities on the environment. A considerable proportion of this new legislation was directed towards the mining industry, and in some cases many old statutes were revitalized and amended to control mining activities (e.g. The Canada Fisheries Act and Northern Inland Waters Act). Much of the legislation pertaining to mining required the reclamation of disturbed lands. However, the requirements and approach taken varied greatly from province to province and between the different levels of government.

The changing approaches to reclamation can be identified as a number of phases in the historical evolution of more stringent legislative measures. Although mining firms have always been responsible (to varying degrees from province to province) for the physical condition of the mine site on closure of the mine, much of the effort in the past was directed towards a general cleanup or to satisfying minimum health and safety standards (figure 2). Historically, the earliest phase in the formal integration of reclamation in the mining process began in the 1960s with the introduction of general clauses in mining legislation requiring the levelling, cleanup and some revegetation of abandoned mine wastes (e.g. early Alberta coal strip mine reclamation regulations). In later stages of this phase, amendments or entirely new mine regulations were introduced requiring specific reclamation procedures be undertaken on the abandonment of a mine. The emergence of requirements for pre-production planning of environmental controls and reclamation began towards the end of the decade for new mines or expansions to existing ones.

The second and most dynamic phase occurred in the first half of the 1970s when a great influx of legislation introducing environmental protection measures began to supercede mining legislation in most provinces. This phase is characterized by the introduction of separate requirements for preplanning of reclamation for various stages of mining; the first cases of predetermining end land use; the use of inspection, penalties, and bonds, and the creation of referral systems for mine developments among the major departments and agencies, with the newly created Environment departments playing the key coordinating role. An integral part of this phase was the gradual introduction of specialized policy statements and guidelines controlling various aspects of the resource management field, all of which had a direct effect on mine development and reclamation.

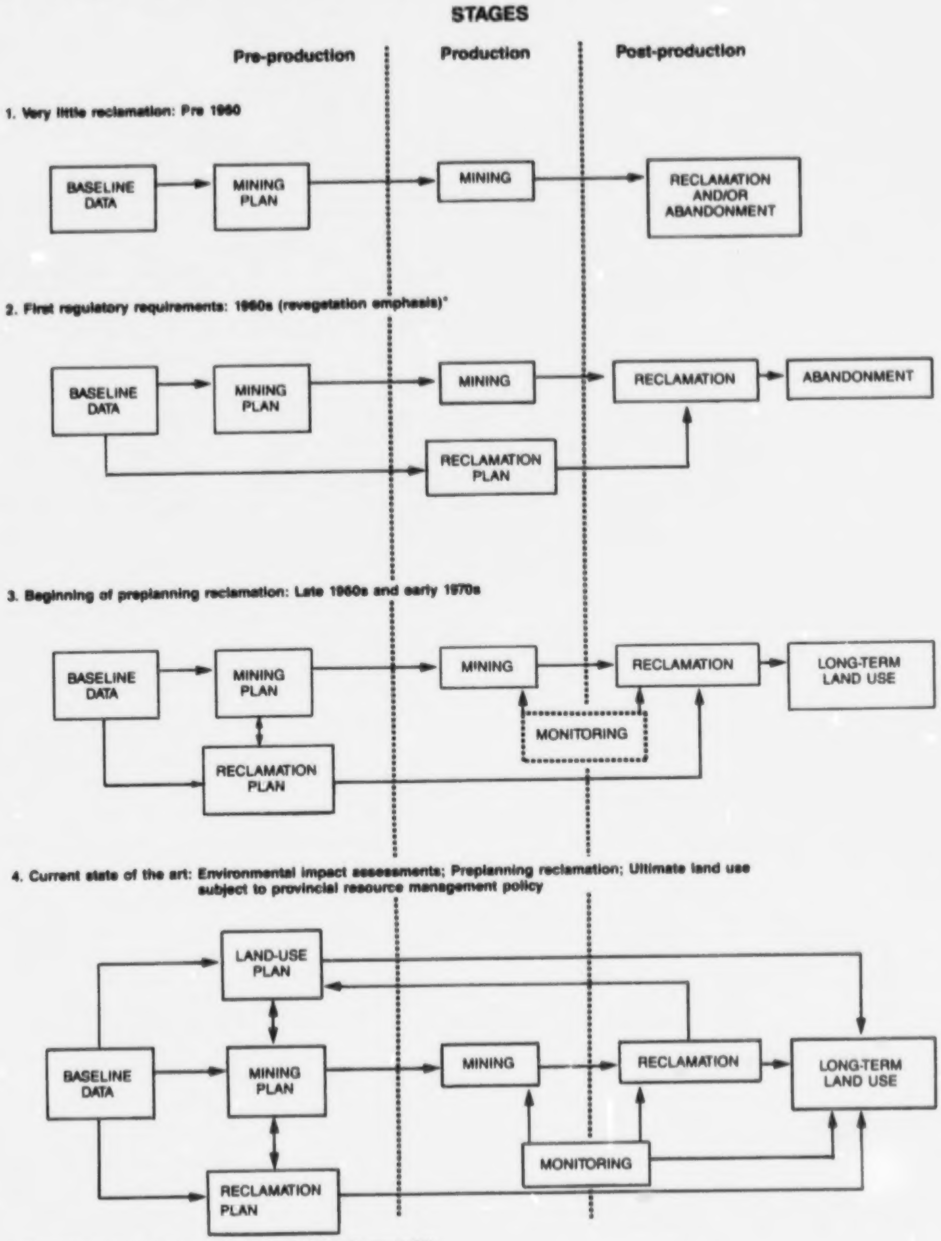
The final phase reflects the "state-of-the-art" in the overall approach towards environmental protection in the mining industry and the general attitude towards environmental affairs that has emerged in the 1980s. Additional requirements may not be found in existing regulations or standards, hence, an integral part of future reclamation plans is the attachment of additional site specific conditions to the lease and/or permit to operate. This allows for flexibility on a site-to-site basis within the context of the legislation pertaining to the mining industry.

Today, most provincial and territorial requirements for reclamation have placed the responsibility of returning formerly mined lands to some useful or aesthetically pleasing condition on the operators. Although some operators may still believe that reclamation is not an integral component of the mining process, as a consequence of the new legislation, it is now integrated into both the preplanning and operational stages of mining operations. Accordingly, if concurrent reclamation is practised, it can be carried out more effectively and at lower costs than when it is considered to be part of the mine closure phase.

The prime objective of final abandonment is to find the best means available of ameliorating all of the deleterious effects that mining activities have had on the land

Limestone quarry, south of Ottawa, Ontario
Robert Audet, Environment Canada

FIGURE 2. SCHEMATIC ILLUSTRATION OF THE HISTORICAL EVOLUTION OF APPROACHES TO MINE RECLAMATION


STAGES
Pre-production
Production
Post-production
1. Very little reclamation: Pre 1960
BASELINE DATA
MINING PLAN
MINING
RECLAMATION AND/OR ABANDONMENT
2. First regulatory requirements: 1960s (revegetation emphasis)*
BASELINE DATA
MINING PLAN
MINING
RECLAMATION
ABANDONMENT
RECLAMATION PLAN
3. Beginning of preplanning reclamation: Late 1960s and early 1970s
BASELINE DATA
MINING PLAN
MINING
RECLAMATION
LONG-TERM LAND USE
MONITORING
RECLAMATION PLAN
4. Current state of the art: Environmental impact assessments; Preplanning reclamation; Ultimate land use subject to provincial resource management policy
LAND-USE PLAN
BASELINE DATA
MINING PLAN
MINING
RECLAMATION
LONG-TERM LAND USE
MONITORING
RECLAMATION PLAN

*There are some cases of this approach being adopted voluntarily prior to 1960

and water resources both within and around the mine site. Many of the potential problems can be handled readily in the general cleanup phase, but the bulk of the attention will focus on reclamation measures. In some provinces additional reclamation objectives for specific land uses have been suggested as part of long-term resource management and land use planning initiatives.

Although there appears to be some orderly progress in the historical evolution presented here, it should be noted that not all provinces are practicing "state-of-the-art" approaches to reclamation. In fact, elements of each of these phases are still in force across Canada. Each province has followed its own individual path in attempting to resolve environmental problems in general and reclamation problems in particular.

In this review of regulatory requirements, a detailed account of all the laws affecting mining and the environment is impractical and would rapidly become obsolete as new control legislation is instituted. Attention is therefore focused on those acts, regulations, policies and guidelines which have led to increased requirements for land reclamation.[2] The fundamental concepts are reviewed and illustrated with existing and proposed legislation. The impact the legislation has had on the implementation of reclamation is discussed in addition to the identification of the current trends in legislation and controls in the mining industry.

MECHANISMS OF CONTROL

Legislative and enforcement controls in Canada provide a complete range of enforcement concepts, ranging from those which spell out detailed requirements, through those which present only general criteria or policy statements, to those where the reclamation is conducted under an agreement or memorandum of understanding attached as a condition to a licence, lease or permit. There are two broad categories of control mechanisms: statutory and non-statutory or discretionary.

STATUTORY

Statutes are Acts that have been passed by the Parliament of Canada or a provincial legislature. The basic elements of the law are set forth in the statutes. In resource management legislation, the statute ordinarily provides for the details of a program to be spelled out in regulations.

Regulations are laws which are not enacted by Parliament or a provincial legislature but are made instead by the executive (i.e. usually the Governor-in-Council (Federal Cabinet), or Lieutenant Governor-in-Council (Provincial Cabinet)), when so authorized by an act or a regulation generally has the same force in law as a statute.

DISCRETIONARY POWERS

The control mechanisms included in this category are policy statements, guidelines, standards, licences (permits, leases, etc.), criteria or codes of practice which usually can be enforced under authority of statutes or regulations. Discretionary powers usually arise from the authority of a regulatory agency to apply or enforce certain requirements as part of a licence, permit, order or lease, etc. that is legally binding. The authority for the licence, permit, order or lease, etc. must be derived from a statute or regulation.

Policy is generally considered as a course of action adopted by the government. Policies have varying degrees of political commitment, depending on whether the policy is expressed in a statute or regulation which is legally binding or through guidelines, standards or codes of practice, etc. Generally, there is more discretionary application of policy when expressed through guidelines or codes of practice in the permit or licence approval process. The highest legal form of a new policy statement is the passage of a new Act and/or Regulations.

Guidelines take many forms, and are often set on a site to site basis. Varying in importance, they may be informal guides to assist agencies in applying regulations, reaffirming policy statements, making statements of long-term objectives or establishing non-statutory requirements which are similar in importance to regulations.

Licences, permits, and approvals (depending on the subject or jurisdiction involved) are instruments of control common to most environmental acts (including all mining acts). Each operation is usually required to obtain a licence or permit which contains conditions relating to any form of pollutant or disturbance activity affecting the natural environment. They may be amended or rescinded in accordance with legal procedure provided in the statute or regulations. The terms of the licence are usually closely tied to departmental discretionary powers.

Standards or **Objectives** indicate levels of exposure to pollutants which should not be exceeded; they may be mandatory or discretionary, usually in the form of effluent or emission standards. A mandatory standard would be one enacted as a regulation, such as the federal Metal Mining Liquid Effluent Regulation (1978, C.R.C. chapt. 819). An example of discretionary standards is the Pollution Control Objectives for The Mining,

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[2] It should be noted that the resumes of the legislation are necessarily brief; moreover, they have been prepared by the author who is not a member of the legal profession. The reader, therefore, is advised to consult the appropriate federal and provincial statutes for more complete reference to the statutes, regulations, guidelines and standards.

Smelting and Related Industries of British Columbia issued by the Pollution Control Board in 1979. In terms of land reclamation the reclaimed land may have to be returned to a certain standard and/or type of biological growth after a given number of years. Criteria are usually scientific requirements on which a decision or judgement may be based concerning the establishment of standards or objectives.

Some guidelines, standards, codes of practice, etc. may have no legal basis for enforcement and simply be nothing more than recommendations or technical advice. Most of these mechanisms are implemented on a discretionary basis as part of the terms of licence or permit approval. Generally, they indicate the parameters or areas of concern that the regulatory or licencing agency reviews in considering individual mine proposals for reclaiming disturbed lands. Some are very broad and open to considerable interpretation, while others may be much more definitive. The latter often involve the use of specific objectives, criteria or standards for individual sectors of the mining industry, or individual operations during the life of a mine. Guidelines are often administered on a site-to- site-basis.

GENERAL ENVIRONMENTAL CONTROL MECHANISMS

Acts and regulations that are general in nature, can be used under certain circumstances to enforce some aspects of land reclamation or curtail continued land degradation practices. The air and water pollution control requirements dominate this category. For example, the proposed Nanisivik mine in the N.W.T., first had to get a lease of the land from the Crown through the Canada Land Act. This Act allowed the federal government to grant leases, and under the Act it can add any conditions desired, even though conditions are not present in any other statute.

Although not directly aimed at mining, the non-specific regulations and standards set for acceptable levels of contaminants entering the environment especially air and water, have had a significant effect on the development of land reclamation at mine sites. At some mine sites, the erosion of waste dumps and tailings sites increased the potential for toxic and for non-toxic sediments to enter the natural drainage network or the atmosphere. Often the recommended means of reducing the amount of pollution from such sources was to stabilize the waste materials through revegetation techniques (or with other chemical and physical techniques). The open-ended nature of the legislation is well illustrated by a number of the general prohibition clauses found in provincial statutes:

1. ***"No person, either directly or indirectly, shall cause, suffer, or permit the contamination of air, soil, or water in excess of prescribed limits". (Manitoba Clean Environment Act; S.M. 1972, C.76; amended 1974 C-41; 1976, C-17).***
2. ***"The Minister may issue a control order requiring the person to whom it is directed to do one or more of the following, namely:***
    a) ***to limit or control the rate of discharging, emitting, leaving, depositing or throwing of any contaminant or waste into or upon the environment, or any part thereof, in accordance with the directions set out in the order;***
    b) ***to stop the discharging, emitting, leaving, depositing or throwing any contaminant or waste into or upon the environment, or any part thereof, (i) permanently, (ii) for a specified period, or (iii) in the circumstances set out in the order (New Brunswick Clean Environment Act; R.S.N.B. 1973, C-6; amended 1974, C-4; 1975, C-12, C-19, 1976)."***

The great influx of general environmentally related legislation on the statute books occurred in the period between 1967 and 1973. The legislation in this early period focused primarily on clean air and water standards, public health, and the protection of fisheries and wildlife. Federally, several Acts with environmentally related clauses were passed or amended in 1970, most of which have subsequently been further amended or strengthened with additional regulations, guidelines and standards.[3] In the same period, similar legislation was passed in all the provinces. An additional feature of the legislation at the provincial level was the establishment of more all-encompassing legislation (e.g. Environmental Quality Act (Quebec, 1972), Environment and Land Use Act (British Columbia, 1971), and the Environmental Protection Act (Ontario, 1971)). Provincially and federally, the need for a mechanism to administer the new Acts and regulations led to the establishment of entirely new environment departments or environmental agencies associated with existing departments. A summary of environmental legislation affecting mining activities is listed in Appendix 1.

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[3] For example. Canada Water Act, Clean Air Act, Fisheries Act, Navigable Waters Act, Inland Waters Act, Arctic Waters Pollution Prevention Act, Territorial Land Act, *see* Appendix 1).

SPECIFIC RECLAMATION REQUIREMENTS

Specific requirements for reclamation (revegetation or rehabilitation) are governed either by regulations and guidelines or by the minister through his authority to grant or refuse a licence to operate. In this case, requirements for reclamation related activities are specifically stated in the various statutes and supporting non-statutory documents.

Summaries of specific statutory and non-statutory control mechanisms in force in each province and the territories are given in Table 1 according to area or method of land control, enforcing department or agency, reclamation requirements, bonds or security deposits in force. Comments on current policies and guidelines in force, pending legislative changes and the general overall approach to reclamation are also included.

It is evident from Table 1 that there is a wide range of specific control mechanisms associated with reclamation in Canada. Despite the disparity in detail, many of the control measures are imposed by "Preventative" or "Reactive" means (Castrilli, 1977). Preventative controls are implemented by an agency prior to project implementation or at periodic intervals during its operational life (for example; in cases where progressive or concurrent reclamation is subject to annual inspection).

Reactive controls usually deal with situations in which an activity may proceed without prior approval, but is subject to control retroactively if pollution prohibitions or standards are violated. Retroactive implementation of reclamation requirements has taken place in mines that were still in operation after the date of establishing reclamation requirements in new statutes, regulations, policies or guidelines. In many cases a licence is given to a new mine to proceed with operations subject to the development of a reclamation plan, including supporting research where necessary for final cleanup and abandonment. In some cases, retroactive implementation of regulations or conditions of permit can be imposed if reclamation progress has not been made on an annual basis.

LAND TENURE

One of the current problems associated with reclamation of land disturbed in the past has been the question of land tenure. Land tenure is the foremost consideration in the relationship between the land and its resources on the one hand, and the producers of metallic, non-metallic and energy related minerals on the other. Thus, resource development and environmental protection must take place within the context of divided jurisdiction between federal and provincial governments.

Proprietary rights and legislative authority are the two main factors determining jurisdiction over resources and the environment (Thompson and Eddy, 1973). Ownership of all Crown lands and natural resources not previously given over to private hands was granted to the provinces under section 109 of the British North America Act (Manitoba, Saskatchewan and Alberta in 1930). The federal government retained proprietary rights to land and resources in the Yukon and Northwest Territories and offshore within the limits of Canada's continental margins, as well as those underlying certain federally owned lands within the provinces (e.g. Indian Reserves, military bases and National Parks). In general, all Crown mineral lands lying within provincial boundaries are administered by the provincial governments. Table 2 indicates the percentages of Crown and private land held by province and territory. The ownership of mineral rights by the individual provinces clearly constitutes one of the most significant aspects of past, present and future mineral land use. As owners, the provinces may administer mineral lands in any manner deemed fitting and appropriate, and they are constitutionally guaranteed the rights to determine who shall use the mineral rights and when, where and how they should be used, and to exercise regulatory powers over most phases of mining operations. They are also enabled to levy and collect revenue, based on profits, volume of production, or a combination of these methods.

Although the provinces own the mineral rights on most of the lands within their boundaries, many of the early land grants were conveyed with the mineral rights as "fee simple" lots or grants. Thus the rights to certain minerals in significant land areas are no longer within the Crown domain, but are instead owned by individuals and companies.

Many of the disturbed and derelict land problems resulting from past and present mining activities can therefore be attributed to the absence of controls related to abandonment or advance planning that would facilitate good rehabilitation practices. As a result no person or company is responsible any longer for reclaiming the abandoned mine site, since much of the land has usually reverted back to the Crown – federal or provincial. A subsequent purchaser may have acquired the land at a time when no reclamation requirements

TABLE 1. FEDERAL AND PROVINCIAL ACTS AND REGULATIONS REQUIRING THE RECLAMATION OF DISTURBED LANDS

Acts and Regulations	**Land Control and Responsible Department**	**Reclamation Requirements**	**Performance Bonds**	**Comments**
FEDERAL				
• *The Territorial Lands Act*, 1970; amended 1970. • *The Territorial Land Use Regulations*, 1971; amended 1977.	• Control, management and administration of all territorial lands. • Establishment of land use permits and land management zones. (Department of Indian Affairs and Northern Development)	• No person may carry on any work or undertaking on territorial lands without a Class A land use permit issued by the Chief Engineer or Land Use Administrator; or Class B permit; issued by the Land Use Advisory Committee. • The engineer may include in any permit terms and conditions respecting the protection of biological or physical characteristics of the land management zone.	• To ensure compliance with conditions of the land use permit a security deposit may be levied not to exceed $100,000.	• **Federally:** There is no separate Act or regulations pertaining to land reclamation. • **Exemptions:** The regulations do not apply to: (a) anything done in the course of prospecting, staking or locating a mineral claim unless it requires a use of equipment or material that normally requires a permit; (b) lands whose surface have been disposed of by the Minister. • Land Use Regulations do not apply to mining in the Yukon due to the primacy of the *Yukon Placer* and *Quartz Mining Acts*.
• *Atomic Energy Control Act* • *Atomic Energy Control Regulations*	• No direct control. • Applies to all lands in Canada. (Atomic Energy Control Board (AECB)	• Regulates all aspects of uranium and thorium mines and mills licensed by AECB. Includes inspection; monitoring; effluent control; tailings management and all aspects of environmental and health protection. AECB may require reclamation and/or stabilization on mine abandonment as a condition of license approval.		• *Guide to Licencing of Uranium and Thorium Mine-Mill Facilities* describes requirements to obtain a license. • If an applicant chooses to diverge from its provisions, he must demonstrate to the satisfaction of the Board that the alternative method (e.g. reclamation) fulfills the intent and requirements of the regulations. AECB is currently developing interim close out criteria for uranium mines in consultation with Environment Canada, Environmental Protection Service, Provincial agencies and the industry.

NEWFOUNDLAND				
• *Quarry Materials Act*, 1976; amended 1977.	• Control on Crown lands and those private on which material rights are not vested in the owner of the surface rights. (Department of Mines and Energy)	• The 1977 amendment gave the Minister the right to issue regulations providing for the restoration and rehabilitation of pits and quarries. • The weakness of the conditions under the *Quarry Materials Act* is that it applies only to Crown lands.	• The Department of Environment has required the deposit of a performance bond for reclamation before issuing a permit. • To be determined.	• There are no requirements under the Mineral Resources Act for reclamation. • Under the *Environmental Assessment Act* (1980) all new mines or expansions at existing mines must submit a reclamation plan; now a condition of permit approval. • New tougher regulations requiring reclamation are in preparation under the *Mineral Resources* and *Quarry Materials Acts*.
PRINCE EDWARD ISLAND				
• *Planning Act*, 1974 • *Excavation Pits Regulations*, 1976.	• Open excavation on all lands. (Department of Community Affairs (Environment Section))	• Under the *Planning Act* all temporary pits must be reclaimed. • Must slope sides of pits to a run-rise ratio of at least 3:1. Restore the site to a condition that will support ground cover appropriate to its surroundings. • Restoration of permanent pits under this Act is not required except for slope stabilization. • All walls of the excavation pit must be sloped to a run-rise ratio of at least 1½:1.	• None indicated	• No separate Reclamation Act. In Prince Edward Island there has been very little need to pass regulations for reclamation. • Department of Environment must approve reclamation carried out on temporary pits.
• *Environmental Protection Act*, 1975.	• All lands (Department of Environment	• Under the *Evironmental Protection Act* reclamation is required on the cessation of any activity disturbing the land surface.		
• *Oil, Natural Gas and Minerals Act*, 1974.	• All lands	• Under the *Oil, Natural Gas and Minerals Act*, the Minister is empowered to make regulations for the protection and reclamation of the land surface.		

Acts and Regulations	Land Control and Responsible Department	Reclamation Requirements	Performance Bonds	Comments
NOVA SCOTIA • *Environmental Protection Act*, 1973, amended 1975.	• Control on all lands irrespect of ownership. (Department of Environment)	• Minister of the Environment has the right to supervise and control the management, preservation and protection of the environment; and the control of all other acts with regard to preserving the environment from deterioration. • Department of Environment Guidelines for Surface Mining Operations require any new development to: • conduct an Environmental Impact Assessment; • submit reclamation plans; • provide for progressive reclamation where possible; • revegetate and stabilize all lands affected.	• Under new proposed environmental regulations a $2,000/acre bond has been established.	• No separate Reclamation Act. • Currently all land use, sequential land use, and reclamation programs are controlled by the Department of Environment in conjunction with the Department of Mines and Energy, responsible for issuing permits. • *The Environmental Guidelines for Surface Mining* are made a part of the conditions of approval for permits on a site-to-site basis. (Guidelines in draft form to be used on a trial basis until finalized). See Appendix 4.
• *Mineral Resources Act*, 1975. • *Metalliferous Mines and Quarries Regulation Act*, 1967.	• Control on Crown lands only. (Department of Mines and Energy)	• Under the authority of these Acts, the minister has the right to issue regulations covering the restoration-reclamation and rehabilitation of surface lands. • Guidelines for Surface Mining described above under the *Environmental Protection Act* apply under these Mining Acts, through the licence review system.		• Dept. of Mines and Energy reviews all permit/licence applications forwarding them to the Dept. of Environment for review. • A Joint Review Committee of the two departments assesses all applications and sets all operating conditions including reclamation requirements as a condition of permit approval.

• *Pit and Quarry Regulations*, 1979. (Draft)	• Control on all lands irrespective of ownership. (Department of Environment)	• *Pit and Quarry Regulations require:* • *reclamation site plan filed and completed before abandonment;* • *progressive rehabilitation to final grade and contour indicated on the site plan while in operation;* • *stockpile topsoil, fill or waste rock to facilitate rehabilitation;* • *sufficient topsoil should be replaced to raise and maintain a healthy growth of vegetation to adequately bind the soil and prevent erosion; areas so covered shall be revegetated.*	• *Under Pit and Quarry Regulations* a $2,000/acre bond is required.	• Regulations in draft form only, best used as interim guidelines and conditions of approval for a permit to operate.
• *Beach Preservation and Protection Act*, 1975.	• Control over removal/disturbance of all beaches. (Department of Mines and Energy)	• Current guidelines require environmental impact statement, and an approved reclamation plan prior to approval of any new operation.		
NEW BRUNSWICK • *Mining Act*, 1961, amended 1971. • *Mining Regulation 77-58*, 1977.	• Controls bedrock minerals on all lands. (Department of Natural Resources)	• Regulations require every owner, agent or manager of a mine to institute and carry out a program of protection and reclamation of the surface of the land and water courses on discontinuance or abandonment of the mine. • A reclamation program shall be submitted to and approved by the minister. Before giving approval to the program the minister shall obtain approval of the reclamation program from the Minister of Environment and the Minister of Agriculture insofar as the program may affect their responsibilities.	• Under the *Mining Act* the Minster may require a mine operator to deposit a security or bond. The amount not to exceed $500 for each acre of land disrupted from year to year. Includes areas used for surface mining and waste disposal.	• During the course of the mining operation, tailings or other areas which will not be required for future impoundment of tailings should be stablized in conformation with the rehabilitation plan submitted.

Acts and Regulations	Land Control and Responsible Department	Reclamation Requirements	Performance Bonds	Comments
• *Quarriable Substances Act*, 1968. amended 1971, 1980	• Control Quarriable materials on Crown lands and designated shore areas which lie outside Crown lands. (Department of Natural Resources)	• The Minister under the *Quarriable Substances Act* has regulations similar to those described under the Mining Act above, but pertain to Crown land only.		• 1980 amendment prohibits the removal of quarriable substances from a designated shore area where it is likely to cause damage to or erode land within or adjacent to the designated shore area. • Departmental policy does not allow permits to be issued within 1,000 feet of the mean high mark.
• *Clean Environment Act*, 1971 • *Regulation 77.7*, 1977	• All Lands (Department of Tourism and Environment)	• Where a water course is to be crossed and no crossing currently exists then a quarry operator must apply for a 'Water Course Alteration Permit' from the Department of Tourism and Environment. • Applications are reviewed by a 'Land Management Advisory Committee' which can recommend that reprofiling and reclamation be done after extraction.		• The Land Management Advisory Committee has representatives from Lands, Fish and Wildlife, Forestry, and Mineral Resources Branches of the Departments of Tourism and Environment, and Natural Resources
QUEBEC				
• *Mining Act*, 1965, amended 1970.	• Crown lands and private lands with Crown mineral rights. (Ministry of Natural Resources)	• *The Mining Act* provides for ministerial control of the siting of rejected mining wastes (overburden waste rock, liquid or solid residues). He may compel the operator to choose an alternate site to prevent environmental damage by withholding the license/permit.		• No provisions for reclamation under the *Mining Act*.
• *The Environment Quality Act*, 1972; amended 1974, 1979.	• Control of all lands irrespective of ownership. (Ministry of Environment)	• All new mining developments (after 1979) including additions to, alterations or modifications of existing mine developments are automatically subject to an Environmental Impact Assessment and Review procedure. • Environmental impact assessments must be conducted and reclamation plans submitted before a permit is issued.		• The Act does not cover mines in operation prior to the 1979 amendment. • The Act also applies to all borrow, sand and gravel pits, and quarries with areas over 3 ha.

• *Pits and Quarries Regulations*, 1977.	• Control on all lands irrespective of ownership (Ministry of Environment)	• Regulations require: • that a restoration plan be submitted for approval; • that it receive municipal approval; • and that restoration be completed one year after cessation of operations. • Land restoration plan must comprise one or more of the following options: a) the levelling and revegetation of the land (trees, bushes, lawns or farmland); b) Landfill made up of earth, sand or stone followed by surface revegetation; c) Creation of an artificial body of water; d) Recreation area or construction project. • No slope is to be more than 30° from horizontal. • Topsoil and overburden are to be preserved and used later during surface restoration and revegetation. • Land restoration must be carried out concurrently with operation of pit or quarry.	• Under *Pits and Quarries Regulations* a security deposit is required: • $5,000 if less than 1 ha. • $4,000 per ha. if greater than 1 ha. • Multiple Pits: if greater than 5 pits are required for a single project, a single overall deposit of $50,000 is required.	• These regulations apply to all new pits and quarries and any person who enlarges an existing operation after the date of the regulations coming into force.

Acts and Regulations	Land Control and Responsible Department	Reclamation Requirements	Performance Bonds	Comments

ONTARIO
• *Mining Act*, 1970, amended 1971, 1972.
	• Control on Crown land only.	• Under the *Mining Act* there are provisions for the rehabilitation of tailings and processing areas.
		  • Vegetate or otherwise stabilize tailings areas no longer required for future use.
		  • Submit detailed plans for revegetating and rehabilitating disturbed land one year prior to cessation of activities.
		  • Rehabilitation must be completed to the satisfaction of the Chief Engineer.
		• The *Mining Act* is being revised (1982), a new section 161 dealing with reclamation requirements will be introduced. Administration and enforcement of its requirements is to be undertaken by the Ministry of Environment, through an internal agreement with the Ministry of Natural Resources.
			• Bond or security deposit in an amount necessary to complete rehabilitation is determined by the Chief Engineer.
			• There is no established system of security deposits to ensure that operations will be reclaimed.
				• *Guidelines for Environmental Control* in the Ontario Mineral Industry published by Ministry of Environment (1979) are not enforced by any law or regulations except to the extent that any of their provisions may be incorporated into *Ontario Water Resource Act* (OWRA) water licences.
				• Ministry of Environment (MOE) application forms for mining proposals also request that the applicant explain whether all tailings areas on the property will be revegetated or otherwise stabilized since revegetation is the recommended method of controlling acid mine drainage and erosion. But the OWRA does not authorize MOE to require that the work be done. It is voluntary.

• *Pits and Quarries Control Act*, 1971.	• Control on all quarriable materials on Crown and private land in 278 designated townships.
	(Ministry of Natural Resources)
		• Applicants for a licence to operate must submit both a progressive and final rehabilitation plan as part of the overall site plan.
		• Includes final grades, drainage provisions, ultimate pit development, screening, berming, rehabilitation and intended after use. Rehabilitation requirements include stockpiling topsoil and overburden; backfilling, grading and contouring; establishment of stable slopes; erosion control; replacement of topsoil and revegetation.
		All licences may be subject to additional terms and conditions.
			• Security deposit of 8¢ per ton. The maximum security deposit to be paid is $3,000 per hectare for each hectare requiring rehabilitation or where progressive rehabilitation is being practiced, the security deposit may be reduced to a minimum of $1,000 per hectare.
			• The security deposit is forfeited on failure to carry out rehabilitation.
				• A new *Mineral Aggregates Act*, has received first reading in May, 1979. It is designed to remove weaknesses in the existing regulations and operating procedures. However, it has still not received final reading and Royal Assent.
				• A number of supplementary guides have been published to aid in the design of reclamation plans.
				  • A Guide to Site Development and Rehabilitation of Pits and Quarries (Bauer, 1968)
				  • Trees and Shrubs for the Improvement and Rehabilitation of Pits and Quarries in Ontario (Lowe, 1980).
				  • Agriculture and the Aggregate Industry and Rehabilitation of Extracted Sand and Gravel Lands to an Agricultural After-use. (MacKintosh and Mozuraitis, 1982).

		• The Minister may revoke a licence for a contravention of any provision of the site plan, any terms or condition of the licence or any requirement of the Act or regulations.		
MANITOBA • *Mines Act*, 1973 • *Quarrying Minerals Regulations*, 1976.	• Quarry material on Crown land and Crown owned minerals. Section on rehabilitation applies to all lands irregardless of ownership. (Department of Mines, Natural Resources and Environment)	• Under the *Quarrying Minerals Regulations* operators must: • Submit a reclamation plan subject to guidelines defined in the regulations and update it every three years. • Begin to rehabilitate depleted sections 6-12 months prior to suspension of production or complete the rehabilitation plan more than 12 months before depletion of reserves.	• Under the *Quarry Minerals Regulations*: • Security deposit of $5,000 and not in excess of $50,000 for the owner of more than one pit or quarry. • For casual permits a charge of 5¢/cu. yd. is levied in lieu of rehabilitation. • On exploration permits where rehabilitation is required a security deposit of $2,000 or $20/ac is required, whichever is greater in lieu of rehabilitation.	• Landowner(s) must ensure mining operations and end land use comply and are compatible with municipal or district land use zoning and by-laws.
• *Clean Environment Act*, 1972; am. 1974.	• Control over all lands irregardless of ownership. (Department of Mines, Natural Resources and Environment (Clean Environment Commission))	• Under the *Clean Environment Act*, the Clean Environment Commission regulates reclamation requirements through policy guidelines, which are made a condition of approval for operating permits on a one-to-one basis. • Current policy requires either progressive rehabilitation of the site as it is used up, or in the case of metallic mines, the submission of a detailed proposal for eventual reclamation and rehabilitation.		• Under the amended Act additional conditions requiring reclamation may be applied to operations existing before June, 1968 which were issued under separate conditions. The failure to comply can result in the withdrawal of permit or licence.

Acts and Regulations	Land Control and Responsible Department	Reclamation Requirements	Performance Bonds	Comments
SASKATCHEWAN				
• *Department of the Environment Act*, 1972	• Control of all lands, regardless of ownership. (Ministry of Environment)	• The *Department of Environment Act* provides the minister with the authority to control all surface disturbances and issue regulations. In the absence of regulations the Minister regulates future mining development by instituting Environmental Impact Assessment, public inquiries and sets reclamation conditions as a part of licence/permit approval.	• A per hectare performance bond is required to be determined individually	• Surface reclamation Regulations have been drafted *under the Department of Environment Act*, but have not yet been enacted. The preliminary draft does not affect land disturbed prior to the proposed enactment date. However, it will apply to both Crown and privately owned land. • Currently reclamation requirements are handled through the E.I.A. procedures, and are made part of conditions of approval for licence/permits on a site-to-site basis. Now guided by draft "Land Use Policy Guidelines" issued in 1977 and Coal Policy, 1978.
• *Draft Uranium Mining Pollution Control Regulations* 1980	• Control of all lands, regardless of ownership (Ministry of Environment)	• Proposed draft regulations require a mine or mill operator, to submit a detailed reclamation and abandonment plan 12 months prior to cessation of operations of any work. Operator must provide for stabilization and reclamation of mining works and waste materials to minimize pollution. • Reclamation shall commence within 1 month of shutdown and shall be completed within 5 years.		• A Mines pollution Control Branch has been established (Prince Albert) to carry out environmental control in the uranium industry. Reviews all licences and permit applications.
• *Mineral Resources Act*, 164, amended 1966, 1972. • *Pollution Prevention Regulations*, 1970 amended 1980.	• Applies to Crown lands only. (Ministry of Natural Resources)	• Under the Mineral Resources Act a reclamation program is required to protect lands disturbed during exploration activities. An operator is required to conduct an Environmental Impact Assessment prior to commencement of operations.	• Under *Mineral Resources Act* a restoration deposit of $500 for the first acre, and $350 for each additional one.	• Mines Branch, Reclamation and Environment Section reviews all mining company proposals for reclamation. It is likely that these activities will be transferred to Ministry of Environment.

		• The regulations apply to the prevention and control of gaseous, liquid and solid waste pollution resulting from any process of the mining industry or from the development of any mineral resource.		
• *Coal Conservation* , 1976.	• Control of all lands, regardless of ownership. (Ministry of Mineral Resources)	• The Act provides the authority for implementing the E.I.A. and Reclamation requirements of the Coal Policy that are now covered under other legislation. • The issuance and renewable of coal mining licenses under the Act will be conditional upon the applicant meeting the conditions of the various elements of the Saskatchewan Coal Policy (1978). • General reclamation requirements of the Coal Policy state that: • reclamation will be carried out concurrently with mining operations. • operator pays the cost; • specific reclamation requirements be determined on a site-to-site basis, but must achieve a self-sustaining state from an ecological point of view; • provision for local community review of reclamation plans.	• A per hectare performance bond is required. To be determined individually.	
• *Mines Regulation Act*, amended 1971. • *Regulations*, 1976.	• Applies to Crown lands only. (Ministry of Mineral Resources)	• Under the *Mines Regulation Act*, all mines must institute a surface protection and reclamation program and submit a reclamation plan prior to commencing operations. Minister shall obtain approval of the plan from the other departments or agencies affected.	• No bond or security deposit required.	• Reclamation requirements are now covered under the *Mineral Resources Act*.

Acts and Regulations	Land Control and Responsible Department	Reclamation Requirements	Performance Bonds	Comments
ALBERTA				
• *Land Surface Conservation and Reclamation Act*. 1973. • *Land Conservation Regulations*. 1974. amended 1974. 1976. • *Regulated Coal Surface Operations Regulations*. 1974. • *Security Deposit Regulations*. 1974. • *Regulated Oil Sands Surface Operations*. 1976. • *Sand. Gravel. Clay and Marl Surface Operations Regulations*. 1979.	• Control of all lands regardless of ownership. (Ministry of Environment)	• The Act and Land Conservation Regulations provide for the conservation of the land surface and the reclamation of any land surface disturbed for any activity. *Regulated Surface Operation Regulations* require as: 1. Detailed environmental Impact Assessment. 2. Development and Reclamation Plan according to detailed instructions in the individual regulations in question. • All regulated surface operations contain 4 parts dealing with: a) Designation. b) Exploration Approvals: and Reclamation Approvals. c) Development and Reclamation Approvals: d) Particulars of Development and Reclamation plans. • 'Guidelines for the Reclamation of land Affected by Surface Disturbances' (1977) express the Land Conservation and Reclamation Council's expectations with respect to detailed content of applications for approvals of surface lands. rather than the 'Regulations' which are deemed too inflexible for satisfactory application at this time. Until further notice they take the place of Regulations under Section 35 of the Act.	• A security deposit is required for all activities determined individually. Refundable after satisfactory completion of reclamation. For surface coal operations a cash deposit of $5.000 for a small mine and $25.000 for larger ones. or the Minister may require security in the form of a cash deposit based on a rate/tonne mined. Approximate levies to date have been 25¢ to $2.00 per tonne.	• The *Land Conservation and Reclamation Act* and regulations issued under it takes precedent over all reclamation requirements issued under previous acts. • Under the Act approval for all new developments and reclamation requirements are handled through the **Land Conservation and Reclamation Council,** responsible to the Minister. Reporting to the 'Council' and responsible for the various review procedures are the: 1. Crown Mineral Disposition Review Committee. 2. Exploration Review Committee. 3. Development and Reclamation Review Committee. • Appeals are directed to the Minister and his decision is final. Representatives from the following departments are represented on all 3 committees: Agriculture: Business Development and Tourism: Energy and Natural Resources: Environment: Municipal Affairs: Recreation. Parks and Wildlife: E.R.C.B.: and Research Council of Alberta.

BRITISH COLUMBIA • *Mines Act*, 1981.	• Control of all land. (Department of Mines and Petroleum Resources)	• No work other than surface exploration work in mines that are not coal mines shall be commenced without written approval of the chief inspector. Surface exploration work at a coal mine by mechanical equipment that disturbs the surface of the land, must obtain written approval of the chief inspector, and is subject to the same reclamation requirements to open or develop a new mine listed below. • Before developing a new mine the owner, agent or manager shall file with the chief inspector of mines a report and plan of all proposed mine operations that includes a program for the protection and reclamation of the surface of the land and water courses affected by the mine and must include the particulars and maps that may be prescribed. • Programs must be published in the provincial *Gazette* and newspapers specified by the Minister. • Programs are submitted to the Reclamation Advisory Committee which reviews the program and makes recommendations to the minister for final decision.	• A security deposit in an amount to be determined by the minister must be made but not exceeding $2.500/ha of land used or to be used for the mine and the waste disposal of the mine set out in the approved program. • Where the mine fails to perform and complete the program for reclamation and the conditions of the permit in a manner satisfactory to the minister, the minister may apply all or part of the security toward payment of the cost of the work required to be performed and completed.	• The *Mines Act* consolidated the former *Mines Regulation* and *Coal Mines Regulation Acts*. The new *Mines Act* and reclamation requirements are less specific, putting heavier reliance on 'Permit' review and use of guidelines. • Reclamation Advisory Committee has representatives from Environment, Recreation and Conservation, Agriculture, Forestry, Mines and Petroleum Resources departments. The Chairman is the chief mines inspector. • There is overlapping jurisdiction with regard to Quarry Materials on Crown land, under the *Lands Act*, 1974. Control and reclamation requirements are divided between various departments including the Lands Service (Environment), Forestry, Municipalities and Energy Mines and Petroleum Resources. Less than 10% of the pits and quarries are under the direct control of Energy Mines and Petroleum Resources. • Guidelines have been published to assist in the preparation of detailed reclamation programs. They include relevant sections of: • Guidelines for Coal Development (1976); • **Procedures for Obtaining Approval of Metal Mining Development (1979);** • Guidelines for Coal Exploration (1981); • Guidelines for Coal and Mineral Exploration (1977); • Guideline for Reclamation of Quarry Operations; • Notes pertaining to Quarry, Sand and Gravel operations Reclamation Programs (attached to permit applications)

Acts and Regulations	Land Control and Responsible Department	Reclamation Requirements	Performance Bonds	Comments
	• The Minister after considering recommendations may: a) approve the program; b) reject it; c) revise or amend it; d) approve it in its revised form, when approved, a 'permit' is issued authorizing the work subject to compliance with the program. • A permit issued may contain special conditions including those pertaining to the future implementation of the program.			
	• Applications for changes to the program can be made to the Reclamation Advisory Committee. • Operators must submit annual reports on progress of reclamation research and operations. • Requirement for continuous and progressive reclamation of surface disturbances during the entire period of operation.			

TABLE 2. **LAND TENURE IN CANADA**

PROVINCE	LAND AREA (Sq. km)	CROWN HELD Provincial %	CROWN HELD Federal %	PRIVATELY HELD %
British Columbia	948,596	93.4	0.9	5.7
Alberta	661,185	59.9	9.7	30.4
Saskatchewan	651,900	59.8	2.3	37.9
Manitoba	650,087	76.9	0.8	22.3
Ontario	1,068,582	88.0	0.9	11.1
Quebec	1,540,680	92.5	0.2	7.3
New Brunswick	73,437	43.1	2.8	54.1
Nova Scotia	55,490	29.7	2.9	67.4
Newfoundland	404,517	95.0	0.6	4.4
Prince Edward Island	5,657	12.0	0.8	87.2
Northwest Territories and Yukon Territory	3,916,007	0.07	99.92	0.01
Canada	**9,976,139**	**48.8**	**40.4**	**10.8**

Source: Canada Year Book, 1976-77. Special Edition: 1977. Statistics Canada, Ottawa.

were in force, but has in the interim inherited the legal obligation to reclaim the land under new legislation. Although this does not happen often, it tends to be more prevalent in the coal industry.

Two studies commissioned in 1977 on the statutory, reclamation and supply aspects of the mineral aggregate industry in Canada (Barnett, 1977; Environment Canada, 1977) reveal that a major proportion of mineral aggregate production comes from private land, and that extraction from private lands can often be done without constraint except for local municipal or regional by-laws. Much of the backlog of unreclaimed pits and quarries, particularly in Eastern Canada, resulted from the absence of early legislative controls related to reclamation.

Prior to the enactment of much of the environmental legislation that required reclamation of pits and quarries on both Crown and private lands, controls over mineral rights on private lands were extremely limited. Control over surface and subsurface mineral rights in Quebec, Ontario, Manitoba and Alberta was restricted to Crown lands.[4] In Quebec under the Mining Act, Section 5, all mineral substances belong to the Crown. If the land was granted before July 24, 1880, however, the base metal rights belong exclusively to the owner of the surface and the gold and silver rights belong to the Crown. Since most of the St. Lawrence Valley and Eastern Townships were settled prior to 1880, the base metal mineral rights to the greatest proportion of this land are privately owned. Almost 80 percent of the mineral aggregate production comes from lands with privately owned mineral rights.

Distinctions between surface and subsurface mineral rights were made in Prince Edward Island, Nova Scotia, New Brunswick and Saskatchewan at some time in the past. In Prince Edward Island surface materials are not considered to be minerals, and the rights to extract sand and gravel are vested in the landowner. A similar statutory distinction is made in New Brunswick, where surface materials and bedrock are governed by separate Acts. Under the Quarriable Substances Act (1968, amended 1971), the Crown has no control over surface materials on private lands. The effect is significant with respect to the aggregate industry, where 85-90 percent of the pits and quarries are located on private lands, in the most settled areas. A similar legislative distinction is made in Saskatchewan (Table 1). In Nova Soctia the province has control over all mineral rights on Crown and private lands except for limestone, gypsum, and building materials granted with surface rights prior to 1910.

Under the circumstances it is not surprising that so many early mine sites (particularly pits and quarries) remained outside the jurisdiction of various acts and regulations designed to prevent excessive environmental degradation and encourage reclamation. It is only in the past decade that many provinces have introduced new legislation to include the varying definitions of mineral rights and types of land ownership.

FEDERAL REQUIREMENTS

There are no specific acts or regulations in force that require the reclamation of disturbed mine sites under federal jurisdiction. Nor is there any policy or set of guidelines requiring reclamation at mine sites. Most of the federal legislation concerning mining sets national standards as they apply to the pollution of air and water. Since most land related activities are a provincial jurisdiction, the responsibility for reclamation has been left to the province. Generally, reclamation requirements are imposed as a condition of lease in the Yukon and Northwest Territories.

On federal lands north of 60°, where over 99 percent of federal Crown lands are located, there are no less than 25 different acts, regulations and special cabinet directives or policies setting out rules for development. However, in the absence of specific legislation, control of mineral exploration, mine development, and operation usually requires the following permits or licences (Dept. of Indian and Northern Affairs, 1981):

I. Mineral Exploration:	Land Use Permit Prospecting Permit Water Use Authorization or Licence (not always)
II. Mine Development and Operation:	Environmental Assessment Review Process[5] Land Use Permit Prospecting Permit Water Use Authorization or Licence Land Tenure Agreement or Lease

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[4] Control was extended to private lands for pits and quarries in 1971 for Ontario (designated areas only), Manitoba in 1972, Alberta in 1973, and Quebec in 1977.

[5] Has not been applied to a mine as of publication date.

All of the above mentioned licences and permits are under the ultimate jurisdiction of the Department of Indian Affairs and Northern Development. However, most of the review boards or advisory committees have representatives from the territorial government and the departments of Environment and Fisheries and Oceans as well as the private sector. Steps in the processing of land use permits and water use licences are illustrated in Figures 3 and 4.

For the purposes of enforcing reclamation requirements, the federal government has relied on codes of practice and guidelines associated with regulations (under the Fisheries Act and Northern Inland Waters Act (NIWA)), but with no legal effect in and of themselves. This allows the federal environmental agencies to negotiate with mine operators for the incorporation of reclamation requirements during applications for a water use authorization or licence under the NIWA to specify that the control of mine waste water and tailings effluent will be at least as stringent as those specified in the Metal Mining Liquid Effluent Regulations (Fisheries Act).

The primary guide at this time for reclamation is found in the Environmental Code of Practice for Mines (Environment Canada, 1977), which is a technical document describing what is currently regarded as good practice in the design and operation of a mine to minimize water pollution. An essential component is section 5 dealing with "Rehabilitation" which covers general cleanup, long-term control of contaminated effluents, rehabilitation of open pits and mine workings, and rehabilitation of tailings areas *see* Appendix 2 for details).

At this time, Cyprus Anvil Mines Corp. is the only case in which a licence to construct and operate a new tailings pond was not issued until the company had developed and submitted an acceptable abandonment plan, approved by the Territorial Water Board (subject to previous review and recommendations by relevant agencies of the Department of Environment and the Department of Fisheries and Oceans). Since the formation of the Department of Environment, only one mine north of 60° has left its site in an abandoned and potentially hazardous state (Cassiar Asbestos, at Clinton Creek). To date, there have not been any currently operating mines in their final close-out phase on which any reclamation requirements have been imposed. Thus, there is very little research or practical reclamation experience in the closing and cleanup of a mine site north of 60°. This makes it difficult to draft specific regulations for northern conditions.

A more difficult reclamation problem is associated with the rapid expansion of placer mining in the Yukon. Because there is very little experience in reclaiming abandoned placer operations or documented knowledge of the ability of former disturbances to recuperate naturally, many of these areas may be alienated from alternate use for some time to come, or may even be beyond recovery. Because there can be several claims on each stream, it is very difficult to regulate or assign responsibility for either individual or cumulative effects on the downstream environment.[6] The resulting poor water quality has the potential to adversely affect fisheries and existing and proposed federal and territorial land uses such as parks and campgrounds, wilderness areas, wildlife reserves, tourist operations, etc. Regulation and environmental control problems arise from the fact that the Territorial Lands Act and pursuant regulations do not apply to land claimed for placer mining. This precludes any regulating control over methods used by placer miners in exploration, production, and abandonment. Miners have consistently opposed any attempts to have the Territorial Land Use Regulations apply on mining lands. However, conflicts and administrative problems also arise in the management of water resources. The Northern Inland Waters Act (NIWA) does not provide an effective mechanism for control of water use in relation to placer mining because of the large number of operators, the seasonal nature, and the frequent movement of these operations. Under the NIWA the Yukon Territorial Water Board was established to licence all water-use operations through permits and licences. However, the dramatic increase in the number of operations in the past few years has resulted in authorizations to use water without a licence, but subject to terms and conditions determined by the Board on the advice of officials from the departments of Environment and Fisheries and Oceans. Under the terms and conditions of the NIWA, operations must conform to regulations passed under section 33 of the Fisheries Act relating to the deposition of deleterious substances. Since most placer operations have adverse effects on fish habitats, there is considerable problem in resolving renewable and non-renewable resource conflicts. At present the Pollution Control Objectives for Mining, Mine-Milling, and Smelting Industries do not address these problems and consequently are inadequate to ensure the protection of water quality adjacent to placer mining operations.

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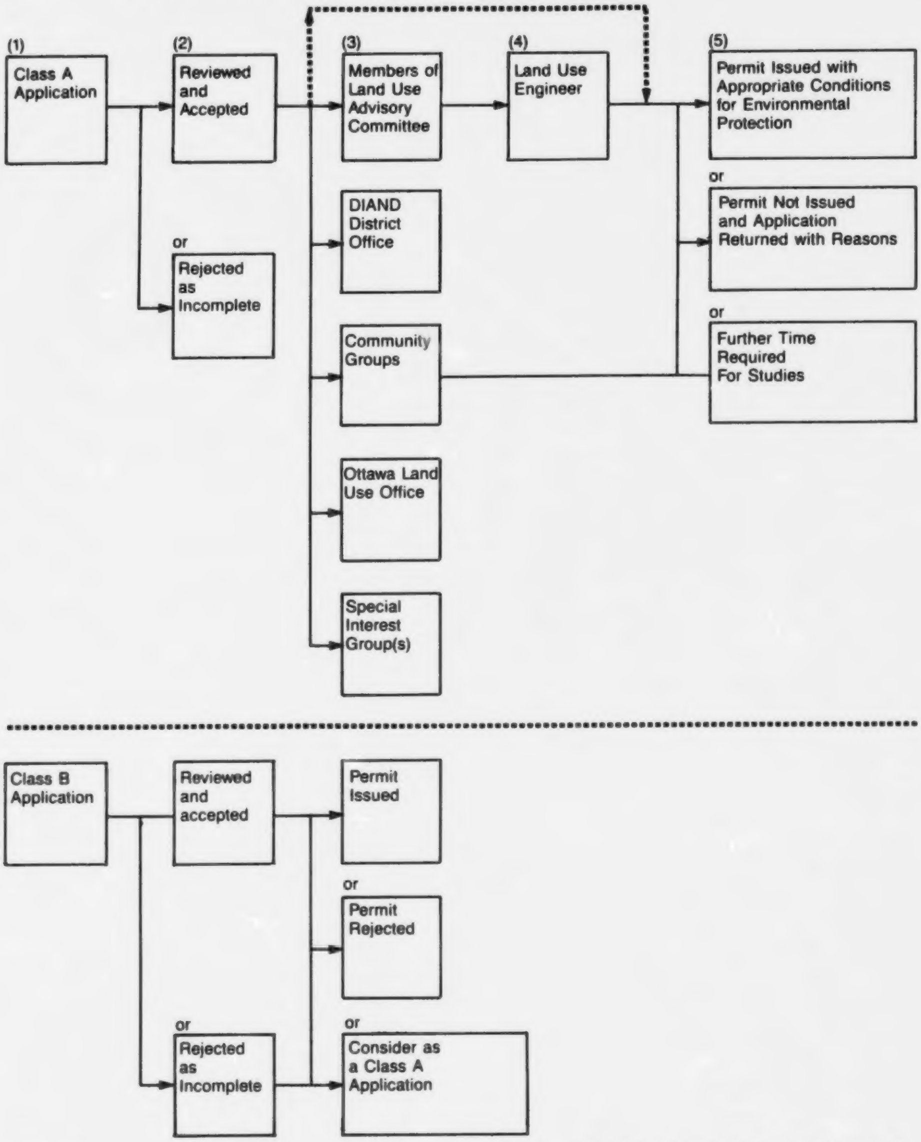
[6] Placer mining is heavily concentrated in four gold fields: the Klondike, Sixty Mile Creek, Mayo in the west central Yukon and Kluane Lake bordering Kluane National Park in the southwest.

FIGURE 3. **LAND USE APPLICATION REVIEW PROCESS: YUKON AND NORTHWEST TERRITORIES**


(1)
Class A Application
(2)
Reviewed and Accepted
or
Rejected as Incomplete
(3)
Members of Land Use Advisory Committee
DIAND District Office
Community Groups
Ottawa Land Use Office
Special Interest Group(s)
(4)
Land Use Engineer
(5)
Permit Issued with Appropriate Conditions for Environmental Protection
or
Permit Not Issued and Application Returned with Reasons
or
Further Time Required For Studies
Class B Application
Reviewed and accepted
or
Rejected as Incomplete
Permit Issued
or
Permit Rejected
or
Consider as a Class A Application

Land Use

In very general terms, a land use permit authorizes a person or company to carry out a specific land use operation at a specified place, during a stated period of time and subject to conditions designed to protect the environment.

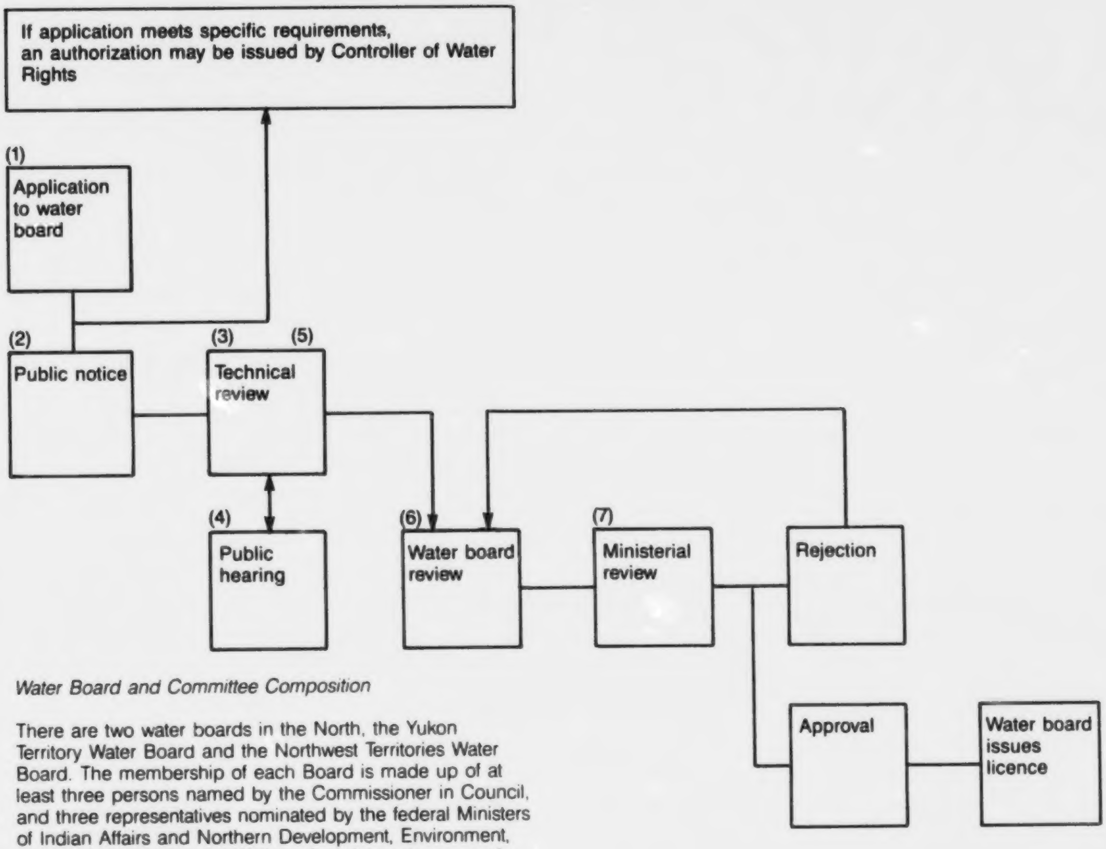
A few small activities, including anything done by a resident of the Yukon or the Northwest Territories in the normal course of hunting, fishing or trapping, do not require a permit. These activities also include anything done in the normal course of prospecting or locating a mineral claim (providing no machinery is used), and operations on lands where the federal government has transferred or granted surface rights to another party. In the Yukon mineral claim holders do not require a permit to work their own claims.

All other operations on Crown land in the Yukon or the Northwest Territories require either a Class A or Class B land use permit, depending on their scope and the size of the area affected. Class A permits are required for all significantly large operations, and any operations in areas of special sensitivity. They may be issued within ten days from the time of application; however, because the Department of Indian Affairs and Northern Development may wish to consult with other experts, the Land Use Regulations provide for a period of up to 42 days from the time the application is received until the applicant is informed whether a permit will be issued.

Class B permits are for small operations and are normally issued within ten days of receipt of the application.

Source: Dept. of Indian and Northern Affairs, 1981

FIGURE 4. **WATER USE LICENSING APPLICATION PROCESS: YUKON AND NORTHWEST TERRITORIES**


If application meets specific requirements, an authorization may be issued by Controller of Water Rights
(1)
Application to water board
(2)
Public notice
(3)
(5)
Technical review
(4)
Public hearing
(6)
Water board review
(7)
Ministerial review
Rejection
Approval
Water board issues licence

Water Board and Committee Composition

There are two water boards in the North, the Yukon Territory Water Board and the Northwest Territories Water Board. The membership of each Board is made up of at least three persons named by the Commissioner in Council, and three representatives nominated by the federal Ministers of Indian Affairs and Northern Development, Environment, and National Health and Welfare. Appointments are made by the Minister of Indian Affairs and Northern Development; he also appoints a Chairperson and Vice-Chairperson from the Current members.

Water Board Technical Committee

The Northwest Territories Water Board technical committee is made up of members from government and industry who have expertise in various fields. The members are appointed by the Board and provide advice on technical matters. The Yukon Territory Water Board has a number of sub-committees composed of Board members who study various subjects and make recommendations to the full Board.

Source: Dept. of Indian and Northern Affairs, 1981

As a consequence, the federal departments of Indian Affairs and Northern Development, Environment, and Fisheries and Oceans are currently formulating new policies and proposed changes to the Yukon Placer Mining Act and Territorial Lands Act. The aim is to introduce new land planning and management mechanisms which will contain the extent of disturbances and meet environmental protection and reclamation requirements. In the absence of adequate legislation, sections 31 and 33 of the Fisheries Act have been the only mechanisms for limiting the effects of all types of mining on the aquatic environment. Regulations dealing with aggregate extraction (pits and quarries) are now outdated and there are no provisions for the reclamation of these lands. Royalties collected are too low to cover the cost of reclamation (a situation that applies to placer mining as well). The government of the Northwest Territories has provisions under the Municipalities Quarry Policy for municipalities to control quarry operations on Commissioner's lands, which require a reclamation fee and an administration fee, but only a few pits come under the policy.

The Atomic Energy Control Act (1946) provides for federal regulatory authority over most aspects of developing, controlling, supervising and licensing of uranium mine and milling operations. Its administration is the responsibility of the Federal Atomic Energy Control Board. Regulation has required provincial co-operation due to provincial ownership of the mineral lands. In the absence of specific regulations covering the closure and reclamation of a uranium mine, however, conditions are established as the Board deems necessary, as part of the licence to operate. The recent closing of two uranium mines (Agnew Lake, Ontario and Beaverlodge, Saskatchewan) have precipated the need to develop new regulations. However, the Board recognized that a number of problems must first be addressed. Consequently, the establishment of final close-out criteria has been delayed. The whole question is still under review by both the federal and provincial departments concerned. The issues include such things as: who is responsible for uranium waste materials, who pays long-term maintenance costs, and what constitutes an acceptable cleanup or reclaimed condition. A national research program on the long-term disposal of uranium tailings has recently been announced by the Department of Energy, Mines and Resources (1982).

Currently, the interim close-out requirements for each mine are written in the "licence" conditions following consultation with the Environmental Protection Service of Environment Canada and provincial agencies. Additional conditions can be attached to the "lease" to use the land by the province. They cannot be less stringent than the federal requirements, but they can be stricter and more expensive of they so desire.

PROVINCIAL REQUIREMENTS

ATLANTIC PROVINCES

The only Atlantic province to amend its Mining Act to introduce new reclamation requirements was New Brunswick in 1977. The newly established requirements under Regulation 77-58 are general in nature and lack the formalized referral systems set up in legislation of some western provinces (e.g. Alberta, Manitoba, British Columbia). However, it has followed a similar trend in the basic requirements, such as:

(1) All mines must carry out a program of reclamation and protection of the surface of the land and water courses on discontinuance or abandonment of the mine.

(2) During the course of the mining operation, tailings or other waste areas which are no longer required for future use should be stabilized in conformation with the rehabilitation plan submitted.

(3) The rehabilitation plan must be approved by the Minister or his designate.

The second and third requirements reveal the increasing demand by the provinces for reclamation to be progressive throughout the operation of a mine (where feasible) and no longer left to the actual cessation of mining operations. The submission of reclamation plans for approval and their enforcement provides for an earlier start on planned progressive reclamation. The final decision on the reclamation procedures to be adopted is left to the responsible regulating department with the final appeal to the minister or cabinet.

New Brunswick was the first Atlantic province to implement reclamation in the 1960s, at its coal operations in the Minto region. Despite changes in legislation, the Quarriable Substances Act still applies to Crown lands only, therefore cleanup and reclamation of disturbed private lands remains outside the law. This will change as regulations and policies under the Clean Environment Act are gradually introduced. Already, new policy directives forbid the extraction of sand and gravel from within 1000 feet of the high tide mark of beaches. Similar protection is now afforded beaches in Nova Scotia under the Beach Protection Act, including reclamation requirements.

Before the enactment of the Quarry Materials Act in 1976 reclamation requirements for pits and quarries were almost non-existent in Newfoundland (Carter, 1981). Reasons given for this situation were: insufficient manpower to enforce the regulations; the too "general" nature of the regulations; and the existing land tenure system (Carter, 1981). In terms of land tenure, reclamation requirements applied only to producers operating on Crown lands. Those operating in fee simple mining grants or other private property were not subject to regulations (approximately one-fifth of the aggregate produced was from such private properties).

Throughout the Atlantic provinces there are few cases in which the provinces have written regulations or guidelines concerning reclamation requirements. The norm, has been to use general clauses giving the minister discretionary power to implement environmental protection measures and reclamation requirements as deemed necessary. Prince Edward Island has seen little need to introduce specific regulations, as it has only limited sand and gravel extraction operations. It has chosen to enforce the cleanup of disturbed lands through the permit approval process of the Environmental Protection Act and Planning Act.

To overcome the problem of private versus Crown land rights, and the general lack of reclamation requirements in mining legislation all Atlantic provinces have turned to Environmental Impact Assessment procedures under existing Environment Acts or new ones (e.g. Newfoundland) to impose future reclamation requirements at currently operating or future mines at the permit approval stage (This aspect will be dealt with in more detail in a later section of this chapter). A problem common to all provinces is the backlog of unreclaimed mine sites not covered by the new legislative and policy initiatives.

Two Atlantic provinces are in the process of drafting more specific regulations - Newfoundland and Nova Scotia. Newfoundland proposes to amend the existing Mineral and Quarries Act, while Nova Scotia has already prepared a draft of proposed new Pits and Quarry Regulations and Guidelines for Surface Mining (*see* Appendices 3 and 4 for the relevant sections dealing with reclamation requirements).[7] In both cases they are issued under the Environmental Protection Act and drafted in cooperation with the province's Department of Mines and Energy. As a result, the new reclamation requirements will apply to all lands, and provide for more coordination through a Joint Review Committee. A similar Land Management Advisory Committee has been established in New Brunswick under the New Brunswick Clean Environment Act (Regulation 77.7).

ONTARIO AND QUEBEC

In Ontario and Quebec early Mining Acts are still the main legislative control affecting the implementation of reclamation for all mines (excluding pits and quarries). Although there is considerable difference in their respective requirements, neither of the provinces' Mining Acts have been effective in imposing active reclamation programs, primarily because of the general nature of their requirements (Thirgood, 1978). The Quebec Mining Act (1965, amended 1977) is limited to the minister's right to control the siting of rejected mine wastes (liquid or solid) to prevent environmental damage by withholding the company's licence to operate. The Quebec Mining Act still does not contain any section that deals with the reclamation of land surfaces disturbed by mining activities. But in the case of underground mines currently in operation, the sealing of shafts, galleries and other dangerous openings is mandatory by Order 319-80, passed in February, 1980. (Regulation 292, of the Mining Act). This includes quarries and sand pits on Crown lands. Ontario requires that a company revegetate or stabilize tailings no longer required for future use during production, submit a detailed reclamation plan one year prior to cessation of activities, and complete work to the satisfaction of the Chief Engineer. In terms of jurisdiction both Acts are generally restricted to Crown lands. In the case of Quebec, however, private land with Crown mineral rights also falls under jurisdiction of this Act. Overall:

> ***"Legal requirements in relation to reclamation of drastically disturbed land are relatively weak in both provinces. The Mining Act of 1970 in Ontario requires rehabilitation of waste disposal areas after the closing down of mining operations. However, in many instances this is not enforceable because by that time many of the smaller mines have either disposed of their assets or run at a loss for several years prior to closing and, consequently, lack available monies for reclamation purposes. Only the larger mining companies having more than one property are in a financial position to undertake rehabilitation when one of their properties is closed out." (Watkins, 1979).***

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[7] The surface mining guidelines outline requirements for 1) baseline surveys; 2) environmental control for mining operations, 3) environmental monitoring during the mining operations; 4) offsite activities; and 5) contingency plans.

Although the Ontario Ministry of Natural Resources has the power to require security deposits to ensure that sites are reclaimed, it has rarely demanded any deposit at all (Castrilli, 1977; Hawley, 1982, Pers. Commun.).[8] In Quebec, the rehabilitation of mine sites after the end of operations attracted little interest before 1977 (Boivin, 1981).

This situation is about to change with the transfer of jurisdiction and administration of sections dealing with abandonment and reclamation in the Mining Act to the Waste Management Branch, Ministry of Environment; (Hawley, 1982, Pers. Commun.). Under the jurisdiction of the Ministry of Environment it is expected that:

> ***"1) The reclamation of derelict mining lands will largely be achieved by revegetation. Other methods of stabilization of these areas will have to be used when and where revegetation is not feasible.***
>
> ***2) The owner of the land involved, and not the public, will pay for the reclamation of the land.***
>
> ***3) Every attempt will be made to achieve a "walk-away" situation upon the completion of reclamation at any particular property. A "walk-away" situation is exactly what it sounds like: no maintenance and no monitoring." (Duignan and Hawley, 1980).***

At this time, mine operators are expected to follow the ministry's Guidelines for Environmental Control in the Mineral Industry (Ontario Ministry of the Environment, 1981). The section dealing with mine abandonment and reclamation is reproduced in Appendix 5.

In Quebec, a similar initiative was undertaken in 1979, with amendments to the Environmental Quality Act. All new mine developments or expansions to existing mines now have to submit reclamation plans as part of the environmental assessment procedure on a site-by-site basis (details are described in a later section of this chapter, under Environmental Impact Assessment and the Permit Approval System). However, pre-amendment operating mines are exempt from its requirements. Prior to this amendment under section 23 of the original 1972 Environmental Quality Act, the Minister of Environment could demand the submission of a reclamation plan if environmental pollution from an operation was likely to harm or destroy the surface of the soil. But, the separate jurisdiction over mines (Dept. of Energy and Natural Resources) and pits and quarries (Dept. of the Environment) created considerable problems in applying the two Acts.

In both provinces, problems with the aggregate sector of the mining industry originated in the rapid growth of urban centres in the 1960s. Conflicts arose from competing land use requirements, in addition to those conservation and environmental groups advocating exclusion of mining from certain lands. Ontario was the first province in Canada to regulate pits and quarries and provide for their rehabilitation.

When enacted, the intent of the Ontario Pits and Quarries Control Act (1971) was to provide rules and regulations that would accelerate the rehabilitation and minimize the environmental impact of pit and quarry operations in the province, while at the same time providing assurance that the province's requirements for aggregates could be met by sources within Ontario, (Ontario, Government of, 1977). By 1975, criticism of the ineffectiveness of the Act and rising conflicts within the field led the Province of Ontario to appoint a Mineral Aggregate Working Party to examine the operation of the aggregate industry and the related environmental and social concerns of municipalities and the public. The Working Party reported that, five years after the enactment, confrontations still existed and were increasing steadily (Ontario, Government of, 1977).

In the introduction to the Working Party Report it listed its main conclusions, including:

> ***"1. That problems of the aggregate industry are primarily local.***
>
> ***2. That while there is general acceptance within the province that aggregate extraction is necessary, there is also a very real concern by the citizens involved to see that their interests are protected.***
>
> ***3. That there is concern that consistency be established in the administration of the legislation, in enforcement and in ensuring that demand is met equitably from the available sources within the province.***
>
> ***4. That the government has lacked credibility in performance to date as a result of:***
>
> ***1) failure of enforcement***
> ***2) weaknesses in the Act***
> ***3) little evidence of rehabilitation achievement to date." (Ontario, Government of, 1977).***

The Working Party Report made 64 recommendations for changes in the Pits and Quarries Act (1971). After an additional public review by a wide number of interested parties, the Provincial Cabinet adopted a number of major policy guidelines, designed to strengthen licencing and inspection procedures (Yundt and Messerschimdt, 1979). These policy guidelines formed the basis of the proposed new "Aggregate Act" that received first reading as Bill 127 on June 14, 1979 (Ontario, Government of, 1979). The proposed approval process under the new "Aggregate Act" is shown in Figure 5.

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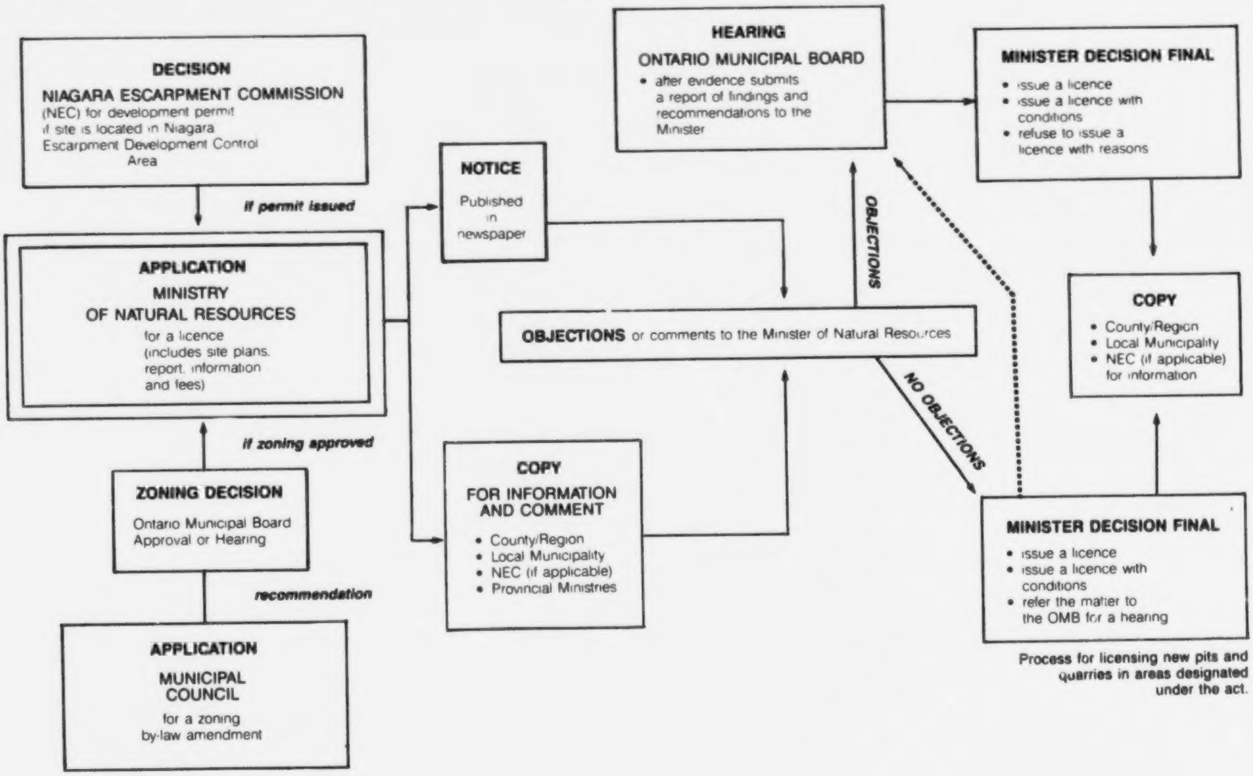
[8] This aspect of the Act has been enforced on only two occasions since 1968-69. (Hawley, 1982, Pers. Commun.).

In the new Bill the Ontario government has recognized that if an operator no longer exists (no longer incorporated, disappeared, bankrupt) or the mine site has been abandoned prior to the passing of the 1971 Act, then part of the cost of reclamation will come from public funds. A public reclamation fund is to be created from the increased licence fee imposed (6 cents/tonne extracted). The fund will be used by the province and municipalities to relcaim abandoned sites, (although there is not nearly enough to relcaim all the backlog of abandoned sites). The system recognizes that today's users must pay for past neglect. Thus it is a form of taxation. If a subsidy from this fund was used to reclaim land and it was subsequently sold within 10 years at a profit, the provincial fund must be reimbursed.

The rehabilitation security deposits establish a further taxation system which recognizes that the main responsibility for reclamation lies with the current operator. The pit or quarry operator and/or landowner must pay any additional amount over and above the security deposits accumulated for the operation, necessary to develop the land to an alternate use. In many cases, this usually results in a more favourable resale value of the land.

FIGURE 5. **ONTARIO AGGREGATE ACT: LICENSING PROCESS**


DECISION
NIAGARA ESCARPMENT COMMISSION
(NEC) for development permit if site is located in Niagara Escarpment Development Control Area
if permit issued
APPLICATION
MINISTRY OF NATURAL RESOURCES
for a licence (includes site plans, report, information and fees)
if zoning approved
ZONING DECISION
Ontario Municipal Board Approval or Hearing
recommendation
APPLICATION
MUNICIPAL COUNCIL
for a zoning by-law amendment
NOTICE
Published in newspaper
COPY
FOR INFORMATION AND COMMENT
• County/Region
• Local Municipality
• NEC (if applicable)
• Provincial Ministries
OBJECTIONS or comments to the Minister of Natural Resources
OBJECTIONS
NO OBJECTIONS
HEARING
ONTARIO MUNICIPAL BOARD
• after evidence submits a report of findings and recommendations to the Minister
MINISTER DECISION FINAL
• issue a licence
• issue a licence with conditions
• refuse to issue a licence with reasons
COPY
• County/Region
• Local Municipality
• NEC (if applicable) for information
MINISTER DECISION FINAL
• issue a licence
• issue a licence with conditions
• refer the matter to the OMB for a hearing

Process for licensing new pits and quarries in areas designated under the act.

Source: Yundt and Messerschmidt, 1979

Already, there has been an increase in the enforcement of site plans; large operators are redoing reclamation plans to incorporate new requirements. There has been a growing overall acceptance and positive attitude towards progressive rehabilitation by the larger operators.

Despite these proposed changes, however, opposition has continued from the Aggregate Producers Association of Ontario (APAO), municipalities, and a wide range of agricultural, conservation, and environmental pressure groups. The opposition to various aspects of the new bill has continued to delay its passage in the legislature. Much of the difficulty in solving this conflict lies in reconciling the authority and jurisdiction between the various departments and the acts they enforce, particularly the Municipal Act, Planning Act, Environmental Assessment Act and specialized planning acts like the Niagara Escarpment and Development Act. Meanwhile, the government has introduced some of the proposed changes under the existing Pits and Quarries Act, by increasing the licence fees to six cents per tonne from two, and rehabilitation security deposits to eight cents per tonne from two, as well as designating most of the remaining townships in southern Ontario so that they fall under the Act.

Quebec was faced with similar problems in the 1970s, but it benefited from the Ontario experience in the development of its legislation. Quebec passed its first Pits and Quarries Regulations in 1977 under the Environment Quality Act (1972) in response to similar problems Division VII of the regulations deals with reclamation. The regulations require municipal approval of proposed new operations and reclamation plans within a year of the cessation of operations, and a security deposit of between $4,000-$5,000 per hectare. Unlike the Ontario legislation dealing with pits and quarries, the Quebec regulations set out areas where pits and quarries may not operate. On the whole the regulations should prove to be adequate to prevent any further sites being abandoned. But the Act does not cover sites abandoned prior to the issuing of the 1972 Regulations. Nor did it establish a per tonne extracted levy to develop a similar provincial fund to reclaim abandoned sites.

WESTERN PROVINCES

The legislative and administrative methods adopted in western Canada to enforce reclamation vary from province to province. With the exception of Manitoba, the catalyst behind the adoption of reclamation laws was the resurgence of coal mining in the late 1960s. But common to all provinces is the commitment to enforcing reclamation, in addition to the early incorporation of its requirements in overall resource management and provincial land use plans.

Alberta's Land Surface Conservation and Reclamation Act (LSCRA), proclaimed in 1973, is the only Act in Canada dealing exclusively with the protection, conservation and reclamation of land. The present LSCR Act provides a uniform procedure to review and approve applications for reclamation orders and certificates of approval, including the following stages (Harrington, 1979):

(i) A development and reclamation application for regulated operations to the Land Conservation and Reclamation Council;

(i) Development and Reclamation approval;

(iii) Reclamation orders;

(iv) Surface control orders;

(v) Security deposits;

(vi) Reclamation in certificates (***see*** Figure 6)

To date specific regulations have been issued covering coal, oil sands, sand, gravel, and clay extraction operations. The central agency throughout this permit approval process is the Land Conservation and Reclamation Council, which can inquire into the condition of any land that has been or is held under a surface lease or right of entry order, or has been or is being used for any surface disturbance. If the council feels that measures should be taken to condition, maintain or reclaim the surface of the land, it may issue a "reclamation order", outlining the measures to be taken and the date by which work is to be completed. When the surface land is in a satisfactory condition, the council issues a reclamation certificate of approval allowing the return of security deposits. Reclamation orders or certificates may be appealed in the court of the judicial district in which the land is situated. The Land Conservation and Reclamation Division, Department of Environment is responsible for administrating the Act. All applications are examined by it through the various review committees and referred to other departments and agencies. Figure 7 illustrates the full range of committees, councils and boards that a new mine development may have to deal with in the process of obtaining approval of its proposed reclamation plan. The Crown Mineral Disposition Review Committee is responsible for reviewing each application for new mine developments according to established guidelines and to recommend the operation for approval or specify necessary modifications to plans.

The Coal Policy for Alberta (Alberta Dept. of Energy and Natural Resources, 1976) outlines the provincial government's objectives in coal development and indicates approval procedures for new developments. While the Coal Policy is province-wide, the Policy for Resource Management of the Eastern Slopes (Alberta, Dept. of Energy and Natural Resources, 1977) specifies land use areas within the Eastern Slopes Region. Eight land use zones were identified, some of which restrict mining activities or dictate the conditions under which they may operate.

Due to the variability of conditions from site to site and the size and type of operations involved, industry requested more flexibility in reclamation standards. In response, Guidelines for the Reclamation of Land in Alberta (Alberta Land Conservation and Reclamation Council, 1977) were issued late in 1977. The guidelines attempted to establish minimum requirements for:

(i) Drainage and erosion control

(ii) Conservation of materials for reclamation;

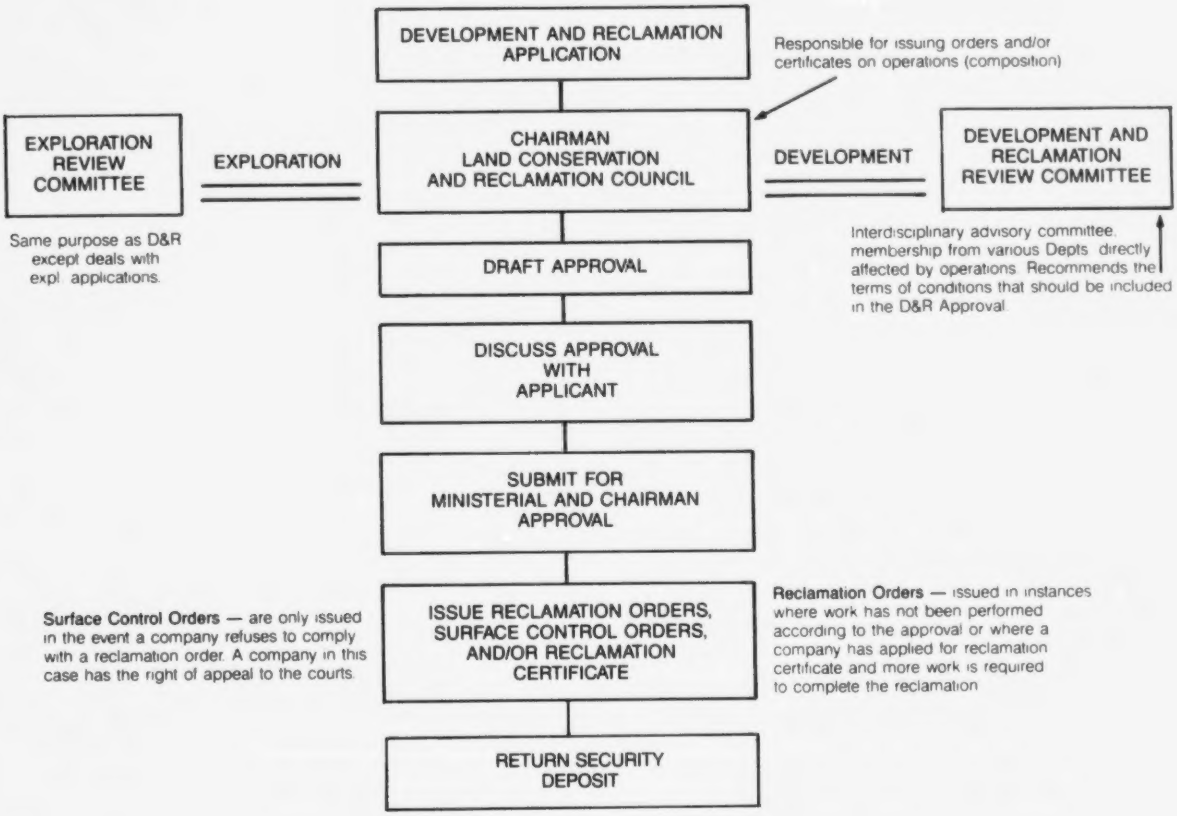
(iii) Backfilling and recontouring;

(iv) Restructuring of the root zone;

(v) Restoration of service and utilities;

(vi) Follow-up land management until full productivity is achieved.

FIGURE 6. ALBERTA RECLAMATION APPROVAL PROCESS


DEVELOPMENT AND RECLAMATION APPLICATION
EXPLORATION REVIEW COMMITTEE
EXPLORATION
CHAIRMAN LAND CONSERVATION AND RECLAMATION COUNCIL
DEVELOPMENT
DEVELOPMENT AND RECLAMATION REVIEW COMMITTEE
DRAFT APPROVAL
DISCUSS APPROVAL WITH APPLICANT
SUBMIT FOR MINISTERIAL AND CHAIRMAN APPROVAL
ISSUE RECLAMATION ORDERS, SURFACE CONTROL ORDERS, AND/OR RECLAMATION CERTIFICATE
RETURN SECURITY DEPOSIT

Responsible for issuing orders and/or certificates on operations (composition)

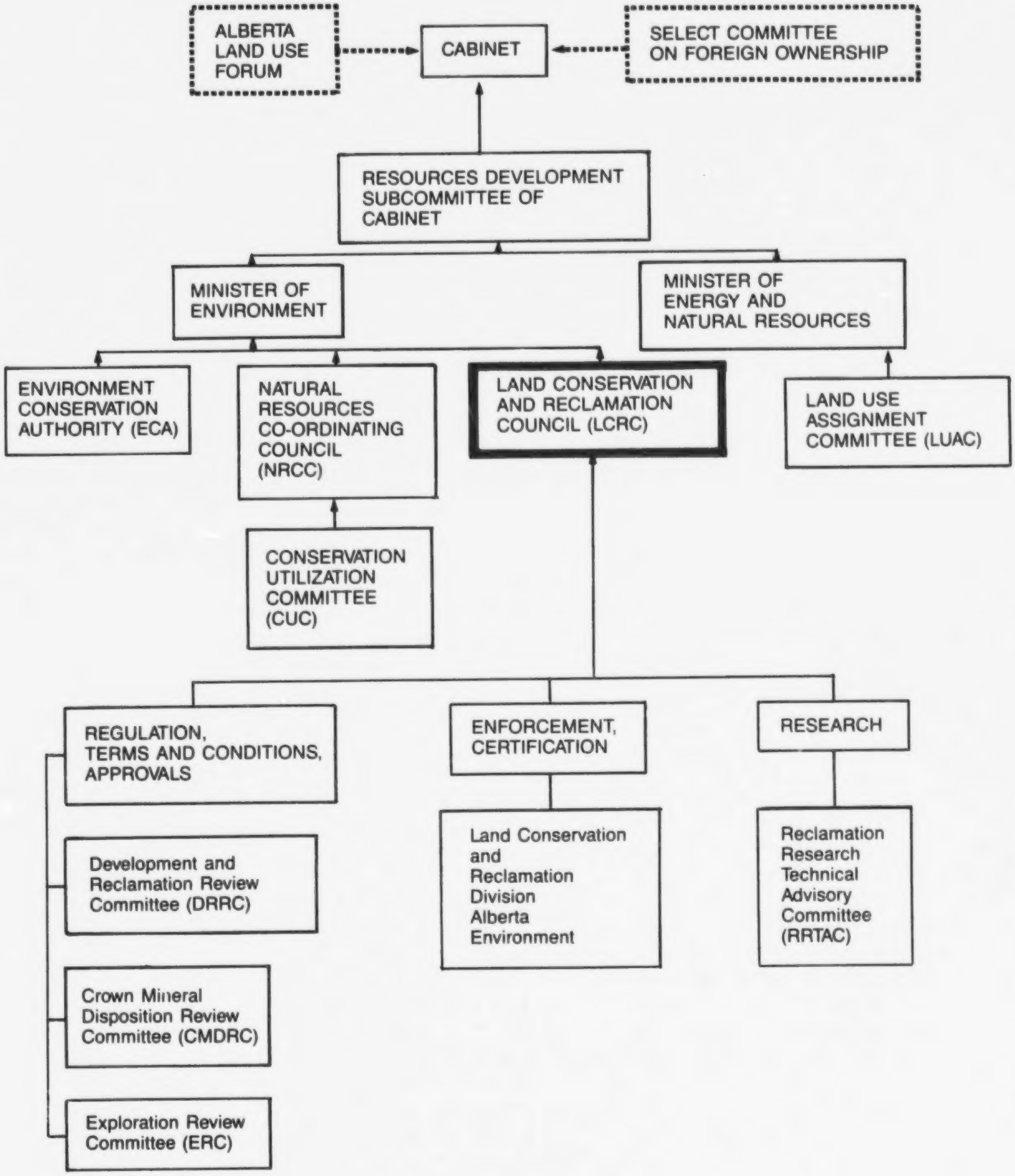
Same purpose as D&R except deals with expl. applications.

Interdisciplinary advisory committee, membership from various Depts. directly affected by operations. Recommends the terms of conditions that should be included in the D&R Approval.

Surface Control Orders — are only issued in the event a company refuses to comply with a reclamation order. A company in this case has the right of appeal to the courts.

Reclamation Orders — issued in instances where work has not been performed according to the approval or where a company has applied for reclamation certificate and more work is required to complete the reclamation

FIGURE 7. **ALBERTA COMMITTEES, COUNCILS AND BOARDS INVOLVED IN THE MINE DEVELOPMENT AND RECLAMATION APPROVAL PROCESS**


ALBERTA LAND USE FORUM
CABINET
SELECT COMMITTEE ON FOREIGN OWNERSHIP
RESOURCES DEVELOPMENT SUBCOMMITTEE OF CABINET
MINISTER OF ENVIRONMENT
MINISTER OF ENERGY AND NATURAL RESOURCES
ENVIRONMENT CONSERVATION AUTHORITY (ECA)
NATURAL RESOURCES CO-ORDINATING COUNCIL (NRCC)
LAND CONSERVATION AND RECLAMATION COUNCIL (LCRC)
LAND USE ASSIGNMENT COMMITTEE (LUAC)
CONSERVATION UTILIZATION COMMITTEE (CUC)
REGULATION, TERMS AND CONDITIONS, APPROVALS
ENFORCEMENT, CERTIFICATION
RESEARCH
Development and Reclamation Review Committee (DRRC)
Land Conservation and Reclamation Division Alberta Environment
Reclamation Research Technical Advisory Committee (RRTAC)
Crown Mineral Disposition Review Committee (CMDRC)
Exploration Review Committee (ERC)

The complete contents of the guidelines can be found in Appendix 6, along with additional requirements for sand, gravel, clay and mine operations. Even with the added flexibility of guidelines additional conditions and interpretation are necessary at the permit approval stage.

The development and approval of reclamation plans are not without problems. There will always be interpretational differences between government and industry representatives on both the method of reclamation and the designated end use. There is still a considerable lack of applied experience in some areas, and dependence on future results from research experiments. Designated post-mining land use can cause further problems, in that it is still difficult to determine what constitutes an acceptable level of reclamation. Many companies feel that more flexibility is needed in the choice of how and to what use mined land will be reclaimed. Industry would like more flexibility in determining the method and final objective of reclamation on a site by site basis. The provincial government can determine land use in the case of Crown lands, but on private lands Regional Planning Commissions, local counties and municipalities determine the final land use through local zoning by-laws and regional plans (Harrington, 1979). Some companies feel there may be a more cost effective method or alternative to the designated land use in leases or permits (for example, industrial, commercial, residential or wildlife rather than agricultural).

The main problem with the reclamation of aggregate pits and quarries in Alberta is inspection and enforcement. Many private land owners still feel they can do what they want on their land. Many establish small operations without going through the application and permit approval process, extract materials before the government has found out about it.

As the results of more reclamation research become available coupled with increased applied experience, it is more than likely that guidelines and standards will be continuously altered from year to year. This is true of most provinces moving towards the use of guidelines and policies in the place of detailed regulations.

Another change in the regulations made in Alberta has to do with the method of paying security deposits. Normally security deposits are payable in cash and held in a trust fund. Companies have been concerned about tying up large amounts of cash in earlier years when it takes several years before reclamation can commence (Harrington, 1979). In response, the province has allowed security deposits in the form of cash, bonds or bond guarantees, although these deposits are not retroactive.

Similar developments have taken place in British Columbia where in 1981 the province replaced the former Mines and Coal Mines Regulations Acts with a single Mining Regulation Act. The legislation covers mineral and coal exploration, placer mining, quarries, gravel pits, metal mines and coal mines. Common reclamation requirements for all mining developments have been established, along with an additional section dealing with unique conditions applicable to coal mining. In general, the requirements have become less specific and a reliance on more flexible guidelines has been established. Reclamation guidelines have been established for coal, metal, sand and gravel, and quarry operations, along with separate guidelines for coal and metallic exploration activities (***see*** Appendix 7 for details of the guidelines).

The approach taken by the province in formulating the legislation was designed to avoid setting any firm regulations until investigation and research had been carried out by each mining company to determine what could and must be done to reclaim the disturbed land (McDonald, 1982). The onus was placed on the industry to develop the reclamation technology in cooperation with the Ministry of Energy, Mines and Petroleum Resources.

The province of British Columbia has put greater emphasis on individual site-by-site permit approval through the establishment of a procedure for obtaining a surface work permit (Figure 8). Like Alberta a central review and coordinating agency, the Advisory Committee on Reclamation, has been established (***see*** Table 1). Overall control and inspection remains in the hands of the Ministry of Energy, Mines and Petroleum Resources, unlike the other western provinces. For new mine developments and expansions of existing mines the surface work permit procedure falls within the broad Environmental Impact Assessment procedure for the province. However, there are still problems with reclamation in the aggregate industry.

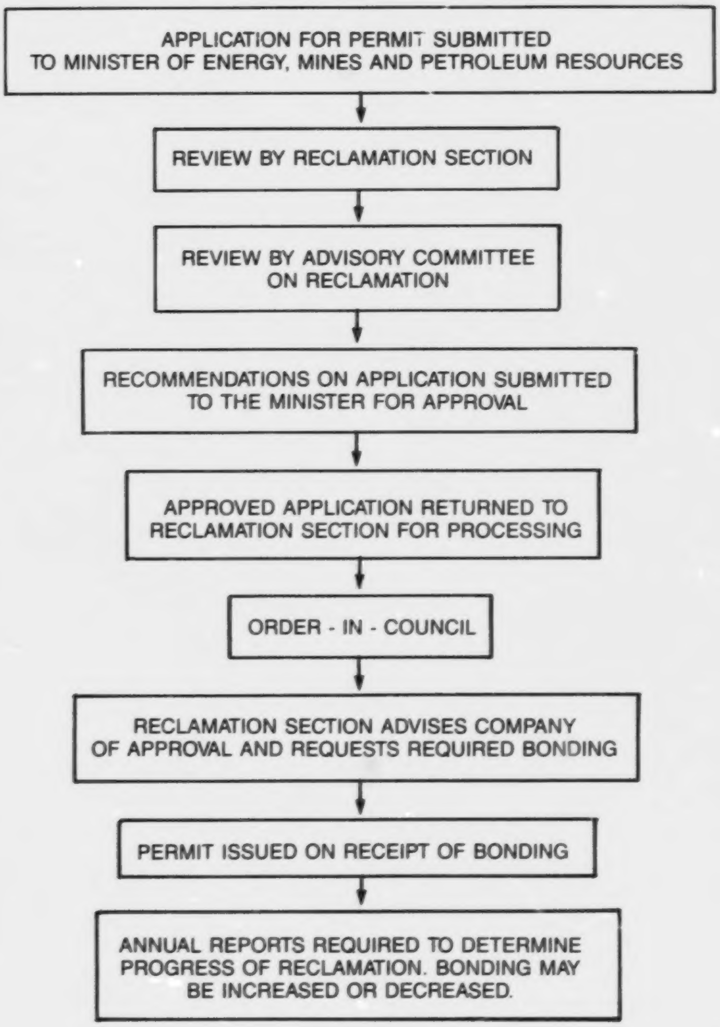
> ***"The image of the aggregate industry is diminished in the eyes of the public when abandoned gravel pits are left unreclaimed or used as dumping grounds for old equipment and miscellaneous junk. During the field survey many sand and gravel pits were observed, par-***

> ***ticularly in rural areas, where very little reclamation had been done. One problem is that there were no rules in the past and the present rules are not the same for all operators and neither is the enforcement. Provisions of the Mining Regulation Act, for example, are not applied to all commercial gravel operations due to staff shortage. The noncommercial production of gravel is not subject to inspection by the Ministry of Energy, Mines and Petroleum Resources. Pits lying within municipalities may be excluded from the Mining Regulation Act (section 10, subsection 17) if reclamation is adequately secured by their by-law. The multiplicity of jurisdictions with the resulting confusion in direction is also a major problem." (Hora and Basham, 1980).***

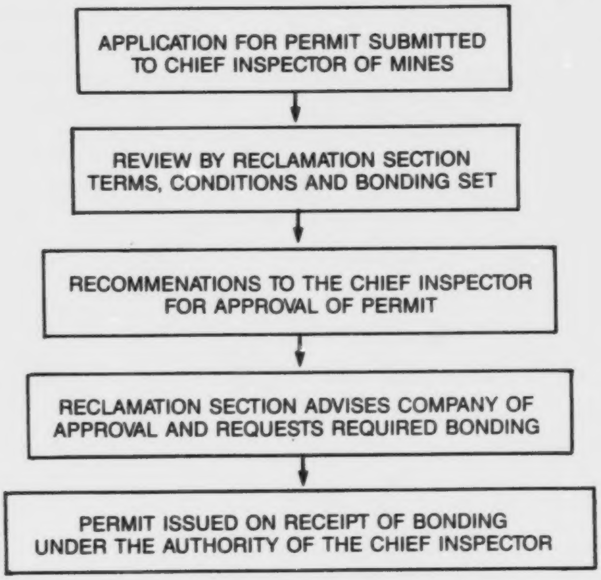
It may take some time before an overall approach to reclamation of pits and quarries can be developed.

FIGURE 8. **PROCEDURE FOR OBTAINING A SURFACE WORK PERMIT AT BRITISH COLUMBIA MINE SITES**

I. PERMIT PROCESSING FOR COAL EXPLORATION, COAL AND METAL MINES


APPLICATION FOR PERMIT SUBMITTED TO MINISTER OF ENERGY, MINES AND PETROLEUM RESOURCES
REVIEW BY RECLAMATION SECTION
REVIEW BY ADVISORY COMMITTEE ON RECLAMATION
RECOMMENDATIONS ON APPLICATION SUBMITTED TO THE MINISTER FOR APPROVAL
APPROVED APPLICATION RETURNED TO RECLAMATION SECTION FOR PROCESSING
ORDER - IN - COUNCIL
RECLAMATION SECTION ADVISES COMPANY OF APPROVAL AND REQUESTS REQUIRED BONDING
PERMIT ISSUED ON RECEIPT OF BONDING
ANNUAL REPORTS REQUIRED TO DETERMINE PROGRESS OF RECLAMATION. BONDING MAY BE INCREASED OR DECREASED.

II. PERMIT PROCESSING FOR MINERAL EXPLORATION, QUARRIES, GRAVEL PITS, PLACER MINING


APPLICATION FOR PERMIT SUBMITTED TO CHIEF INSPECTOR OF MINES
REVIEW BY RECLAMATION SECTION TERMS, CONDITIONS AND BONDING SET
RECOMMENATIONS TO THE CHIEF INSPECTOR FOR APPROVAL OF PERMIT
RECLAMATION SECTION ADVISES COMPANY OF APPROVAL AND REQUESTS REQUIRED BONDING
PERMIT ISSUED ON RECEIPT OF BONDING UNDER THE AUTHORITY OF THE CHIEF INSPECTOR

Note:

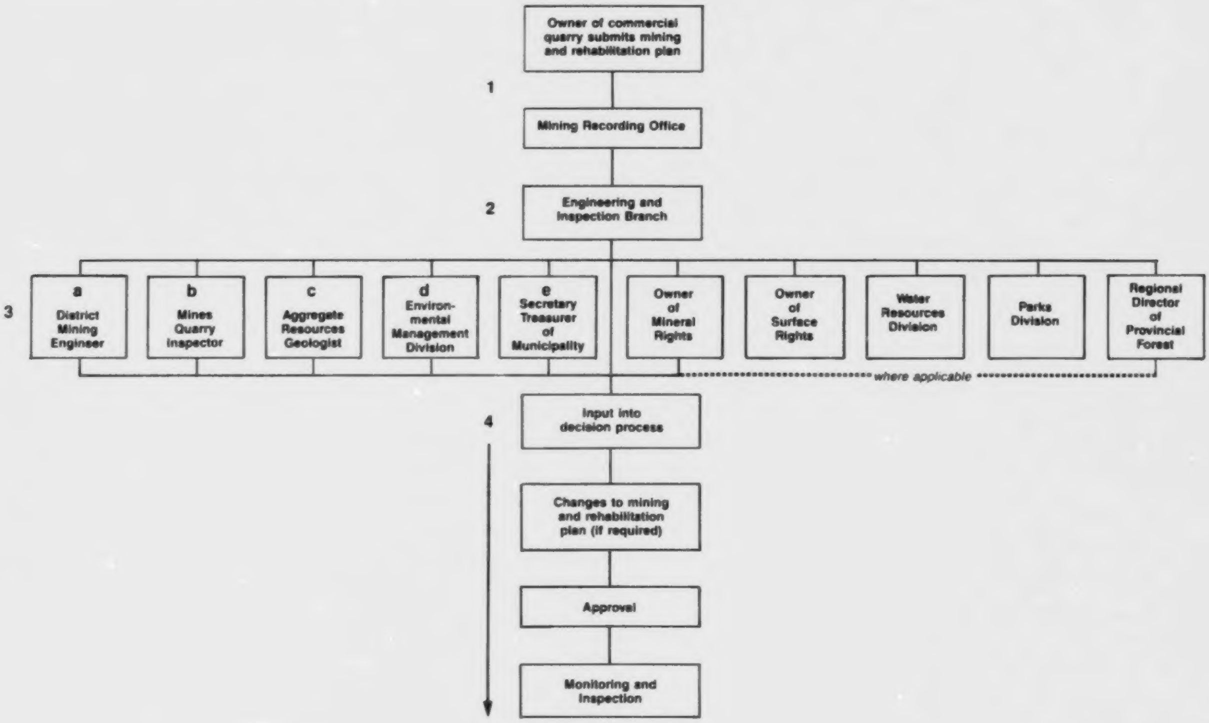
1. Permits are only required when there is more than minimal disturbances and mechanical equipment is used.
2. For large mining companies with a number of exploration projects, a General Reclamation Exploration Permit is issued covering all projects. A $5,000 bond is required.

Source: McDonald, 1982

Saskatchewan is still in the process of developing final regulations for reclamation under the authority of its Environment Act. Up to this time it has relied on policy directives, the environmental impact assessment procedures and permit or lease approval systems to enforce reclamation requirements at new or expanded mine operations. The province enforces reclamation at coal mines through its Saskatchewan Coal Policy (Saskatchewan Department Mineral Resources, 1978) issued under the authority of the Coal Conservation Act. This Coal Policy sets out a number of conditions to be implemented in the final set of reclamation procedures, including:

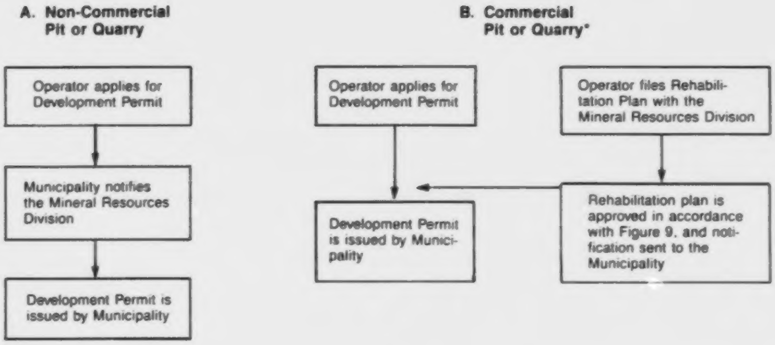
> ***"1) The practice of leaving spoil banks without any further treatment (for example, in some parts of the Estevan area) is unacceptable to the Government. Consequently, some degree of reclamation will have to be carried out for future mining operations.***
>
> ***2) The degree to which land will be reclaimed, as well as the type of reclamation techniques that will be employed, will vary from location to location because of such factors as differences in soil, landform, climate, and desirability of a given land use.***
>
> ***3) Provision will be made to include local input on desired reclamation goals and levels while the reclamation study is in progress. Provision will also be made for local community review of the reclamation plans which are developed after the study is completed.***
>
> ***4) The objective of reclamation plans will be to employ reclamation practices which will allow a stabilization of the soils and will achieve a self-sustaining state from an ecological point of view so that the land may be returned to a productive state as soon as possible. In some cases, a coal producer may be required to modify his mining plans or techniques in order to facilitate reclamation of the land. Examples of such techniques would include selective placement of overburden, segregation of unsuitable overburden materials, and the use of alternative mining equipment.***

FIGURE 9. **MANITOBA QUARRY REHABILITATION APPROVAL PROCESS**


Owner of commercial quarry submits mining and rehabilitation plan
1
Mining Recording Office
2
Engineering and Inspection Branch
3
a District Mining Engineer
b Mines Quarry Inspector
c Aggregate Resources Geologist
d Environmental Management Division
e Secretary Treasurer of Municipality
Owner of Mineral Rights
Owner of Surface Rights
Water Resources Division
Parks Division
Regional Director of Provincial Forest
where applicable
4
Input into decision process
Changes to mining and rehabilitation plan (if required)
Approval
Monitoring and Inspection

Source: Manitoba Department of Mines, Natural Resources and Environment, 1979

FIGURE 10. **ROLE OF MUNICIPALITY AND MINERAL RESOURCES DIVISION IN PROCESSING DEVELOPMENT PERMITS FOR PIT AND QUARRY OPERATIONS: MANITOBA**


A. Non-Commercial Pit or Quarry
Operator applies for Development Permit
Municipality notifies the Mineral Resources Division
Development Permit is issued by Municipality
B. Commercial Pit or Quarry*
Operator applies for Development Permit
Operator files Rehabilitation Plan with the Mineral Resources Division
Rehabilitation plan is approved in accordance with Figure 9, and notification sent to the Municipality
Development Permit is issued by Municipality

*Commercial Quarry: one from which more than 2000 cu. yds. of quarry mineral are removed annually and is operated for any purpose except for the personal use of an owner who is a natural person

Source: Manitoba Department of Mines, Natural Resources and Environment, 1979

5) ***Costs of reclamation will be the responsibility of the coal producer.***

6) ***Reclamation will be carried out concurrently with mining operations." (Saskatchewan, Department of Mineral Resources, 1978).***

The Saskatchewan Department of Environment drafted preliminary surface reclamation regulations in 1976 (*see* Appendix 8). These regulations have been used as guidelines in drafting reclamation requirements as a condition of permit or lease approval under the Environment Act.

Saskatchewan is presently drafting new Uranium Mining Regulations. A draft outline of the reclamation and abandonment section of the proposed regulations is outlined in Appendix 9. The reclamation aspects of coal and uranium mining have been transferred to the Department of Environment. It is expected that new regulations for the potash industry will be drafted once work on the uranium regulations is completed. At the moment, regulation of metallic mines are still caught in a grey area between the Mineral Resources Act and the Environment Act. Eventually, responsibility for reclamation and cleanup of metal mines will be transferred to the Department of Environment. Currently, reclamation requirements under the Mines Act and Mineral Resources Act apply only to Crown lands. The Environment Act has to be used for private lands on an individual permit basis.

Manitoba has adopted an approach similar to Saskatchewan's in that policy guidelines and the permit approval system are used to enforce reclamation requirements through the Clean Environment Commission under the authority of the Clean Environment Act (1972, amended 1974). This requirement applies to mines operating prior to 1968 as well. The Clean Environment Commission reports to the Minister of Mines, Resources and Environmental Management. All orders of the Commission are subject to appeal to the minister, whose decision is final. Previously, the Commission had been given general control and supervision over all matters concerning preservation of the natural environment and prevention and the control of contamination of the environment. The Commission has remained an independent body with quasi-judicial, standard setting and policy recommendation functions. The commission controls the deposition of tailings on or in the soil and any disfiguration of the landscape. Its current policy is to require progressive rehabilitation of the mine site were possible and the submission of detailed proposals for the eventual reclamation and rehabilitation of the mine site. The Mineral Resources Division now oversees the rehabilitation and abandonment of lands affected by mining operations. Most reclamation requirements are applied on a site-to-site basis. However, Manitoba has passed specific Quarry Minerals Regulations (1976) under the Mines Act to regulate and enforce reclamation of aggregate pits and quarries. A guide to the preparation of rehabilitation plans has also been prepared to assist operators (Appendix 10). A formal procedure for submitting reclamation plans, outlined in Figure 9 and Figure 10, indicates the roles of the municipalities in the overall procedure.

Manitoba is attempting to ensure that rehabilitation of pits and quarries takes place during and following extraction on all commercial operations (Manitoba Department of Mines, Natural Resources and Environment, 1979). A system of sequential land use planning is recommended. One of the main aims of the rehabilitation requirements is to optimize the potential for utilization of the landscape during and after the mining operation. The guidelines recognize that it may not be feasible to return disturbed land to their former land use due to environmental constraints. Therefore, the objective is to return disturbed lands to more productive uses wherever possible. To date, reclaimed lands have been used for stock watering ponds; improved wildlife habitat, recreational uses; landfill sites and residential housing (Manitoba, Department of Mines, Natural Resources and Environment, 1979).

MUNICIPAL

Acts providing for municipal or regional by-laws and zoning ordinances may restrict mining activities or require specific reclamation measures to be undertaken. As it is a delegated provincial authority, the provincial legislature can override any municipal by-law or zoning ordinance. The by-laws or zoning ordinances are only rarely less demanding than provincial statutes, and may even have stricter reclamation requirements than the province in some situations.

Zoning ordinances and by-laws cover a wide range of activities. The main emphasis, however, is on land and land use controls. The desire to minimize or prevent adverse environmental effects is a recent but significant addition. Zoning at the municipal and regional levels results in the assignment of one or more priority land uses. Hence, the zoning concept is fundamental to land use planning, forming the key building block to resource management and planning. It can be used, for instance, to exclude mining activities from certain municipal lands. Often a change in zoning to allow mining is coupled with additional by-laws requiring various environmental protection measures.

Often, the true significance lies in the conditions attached to a zoning change and/or permit to operate. Municipalities designate the land use a site must be used for once mining is completed. In most jurisdictions, requirements may already be part of the official plan. For example, in the Regional Municipality of Durham, Ontario, in addition to requirements under the Pits and Quarries Control Act (1971), additional requirements have been enacted by by-law as part of the regional planning process. They require:

> ***"additional information to the satisfaction of the area municipal council: a soils survey describing soil type, organic matter content, depth of topsoil and depth of overburden; a survey of existing surface water systems, and provisions for anticipated changes due to the extraction, and subsequent management practices; a survey of groundwater determining the source of water, quantity, quality, and seasonal fluctuation; a survey of the location and character of existing vegetation systems; and the intended slope of the rehabilitated site and the angle of repose of the material. These agreements must require that pit or quarry operations be conducted in accordance with the site plan, and that financial security, in the form of a performance bond or fund, be posted sufficient to ensure the complete rehabilitation of the pit or quarry." (Castrilli, 1977).***

This is where by-laws play a more important role in the development of reclamation practices. The by-laws can set out necessary standards (environmental conditions) on a site-to-site basis, according to its own particular environmental conditions, which can be included in an application for a permit to operate or a zoning change. The more specific by-law requirements of the District Municipality of Abbotsford (by-law No. 71-1974, sections 91, b and c) illustrates this point with regard to aggregate operations:

> ***"After excavation has been completed, all surfaces must be graded or sloped so that no gradient shall be steeper than 1½ to 1. Also, all surfaces will be covered with no less than 6 inches of topsoil and sown with grass in quantities of no less than 20 pounds per acre." (Hora and Basham, 1981).***

Increasingly, mine operators will be required to preplan reclamation procedures concurrently with the operational side of business in order to convert the mine site to a designated end use. To ensure that reclamation work is done, municipalities are now requiring the posting of performance bonds, some of which are higher than provincial requirements. The District Municipality of Matsqui in British Columbia requires:

> ***"an irrevocable letter of credit totalling $5,000 plus a further amount of $3,000 to a maximum of $20,000 for each hectare of property from which soil is to be removed or deposited." (Hora and Basham, 1981).***

Most performance bond requirements are in the $2,000 to $5,000 per hectare range.

The increasing involvement of local government in the environmental protection and reclamation aspects of the mining industry has not been without its problems. In many cases, the desire to become involved was not the municipalities' choice, but that of provincial legislatives or policy makers. This involvement constitutes one step in a larger provincial review and coordinating process. Municipalities own by-laws or zoning ordinances often are the result of public pressure to cleanup unsightly abandoned sites or control their future location. Desired or not, many municipalities find that they do not have the staff or expertise to review mining environmental problems. This has contributed to misunderstandings and slow response times to industry applications. Another aspect of this problem is the conflicting policies and regulations emanating from different agencies at various levels of government.

The problem of conflicting and overlapping regulations can become a costly and time consuming process for companies which are forced to make multiple submissions to meet duplicated demands by various agencies in the different levels of government. Attempts to overcome this problem have led to the advocacy of the "one window" concept in regulation. This refers to the establishment of a lead agency or controlling committee through which all requests for submissions are channelled. In British Columbia, it is the Mining Steering Committee, while at the federal level the Atomic Energy Control Board acts as the lead agency for all uranium mine activities, convening meetings to coordinate other departmental requirements.

ROLE OF ENVIRONMENTAL IMPACT ASSESSMENTS AND THE PERMIT APPROVAL SYSTEM

The purpose of the Environmental Impact Assessment (E.I.A.) process is usually to provide a comprehensive information base in order to facilitate the early identification and resolution of potentially adverse environmental effects of proposed developments before any environmental damage occurs. The objectives of most E.I.A. processes are:

> ***"(1) Identifying and evaluating all potentially significant environmental effects of proposed developments at a stage when alternate solutions, including remedial measures and the alternative of not proceeding are available to the public and decision makers; and***
>
> ***(2) Ensuring that the proponent of development undertakes to implement the means of avoiding or mitigating any adverse potential environmental effects prior to the granting of any approval to proceed with the proposed development." (Canadian Council of Resource and Environment Ministers, 1977).***

The federal and provincial approaches to Environmental Impact Assessment are outlined in more detail in Appendix 11. In all cases, there is a high degree of agreement with regard to the purpose and objective and a considerable consensus on the scope and content of Environmental Impact Assessments. Major differences in Environmental Impact Assessment occur in its implementation due to the wide variation in the organization of the economic base, natural resource and ecological setting of each province. Canadian governments have introduced E.I.A. procedures gradually over the past decade, first through policies and guidelines under already established Acts, then in some provinces through the introduction of specific Assessment Acts (Newfoundland, Saskatchewan, Ontario) or regulations under Environmental Acts (Quebec, Alberta). Each province has developed unique processes and procedures to reflect its needs and circumstances. As a result, there is no single set of criteria for what constitutes an adequate E.I.A, or what the ultimate role of the E.I.A. procedure is in the overall decision making process. Procedures for implementing an E.I.A. range from very simple guidelines on a site-by-site basis to very formal, elaborate environmental planning mechanisms.

In practice the process has been used in Canada as an overall environmental planning tool, as the main basis for decision making, or as only one component of the overall decision making process. Although the assessment process has been heavily oriented towards being an information gathering device, it is emerging more and more as an essential component of the decision making process, particularly in relation to mineral and energy related developments. Since resources are limited, choices have to be made, and normally they have very high political, economic and social overtones. Hence, most environmental assessments are limited to internal procedures rather than turning decisions over to independent decision making bodies. Most jurisdictions put projects through an internal preliminary assessment to determine whether or not a full public assessment is required. No level of government has been willing yet to establish firm guidelines that determine what will or will not be subject to assessment. In all cases, the degree of public involvement, appeals, final decisions and indeed the actual decision to conduct an Environmental Impact Assessment are very much left up to ministerial or cabinet discretion. During the 1970s the use of Environmental Impact Assessment procedures was the method most widely adopted to provide a more formalized approach to proposals for new mine developments.

Although the approach and requirements of an E.I.A. may vary between provinces and in the territories, its influence on mine development is similar. Throughout the developmemt stage of a mine, two parallel processes are now essential: the first involves the engineering design, layout, and technological requirements normally associated with bringing a mine into production; while the second includes the establishment of a fully integrated environmental protection program that meets all existing regulations and standards for air, water, and land quality. Prospective operators must now collect environmental baseline data, conduct an environmental impact assessment, and, increasingly, conduct a parallel socio-economic impact assessment, and then proceed through a series of formal submissions, public hearings, and applications according to procedures established by the various provinces and territories.

In most provinces new mines are now involved in the long-term use of the land, and hence, there is a need to prepare either for concurrent or sequential land use planning. Much of the ability to return mined land back to a viable post-mining use depends on the introduction of successful reclamation and rehabilitation techniques. Thus, reclamation requirements have become an essential component of environmental legislation and procedures in most provinces of Canada especially with regard to long-term resource management and land use planning. In fact, they have become the major vehicle for implementing reclamation at all new and expanded mine developments. In some cases, they are the only vehicle for implementing reclamation where no provision exists under other acts or regulations.

Five provinces have Environmental Impact Assessment requirements rooted in acts or regulations: Newfoundland Quebec, Ontario, Saskatchewan, and Alberta. The remaining provinces and the federal government rely on cabinet policy directives backed by order-in-council directives issued under the authority of other environmental legislation. However, there are important distinctions to be made in the application of these Environmental Impact Assessment requirements. In New Brunswick, Prince Edward Island and Ontario for instance, requirements for Environmental Assessments do not apply to the private sector. Therefore any application of an E.I.A. process to a private sector development will be at the discretion of the responsible minister or the cabinet. In the case of the federal government, projects which are proposed independently by private corporations are not subject to the Environmental Assessment Review Process (EARP) unless federal infrastructure assistance is contemplated or federal land, money or agencies are involved. Under such circumstances environmental protection measures are limited to those required by existing legislation. With the exception of uranium mines, there have not been any formal federal Environmental Impact Assessments conducted on a proposed new mine. In Ontario the only Environmental Impact Assessment conducted on a private sector mine development occurred in the expansion of uranium mines in the Elliot Lake area.

More importantly, seven provinces (Newfoundland, Nova Scotia, Quebec, Manitoba, Saskatchewan, Alberta and British Columbia) now require that all new mines or expansions at existing mines conduct Environmental Impact Assessments. In most cases the type of assessment and degree of public participation usually vary subject to the discretion of the regulating agency. All seven provinces have the additional requirement that a reclamation plan be submitted as part of the Environmental Impact Assessment. A summary of federal and provincial approaches to Environmental Impact Assessment are shown in Table 3.

Procedures for Environmental Impact Assessment and development approval for new mines vary considerably from province to province. By and large, the most detailed have emerged in western Canada mainly due to the large increase in open-pit and surface strip-mine operations. In most cases, they incorporate a multi-stage procedure which includes the initial determina-

TABLE 3. **SUMMARY OF FEDERAL AND PROVINCIAL APPROACHES TO ENVIRONMENTAL IMPACT ASSESSMENT**

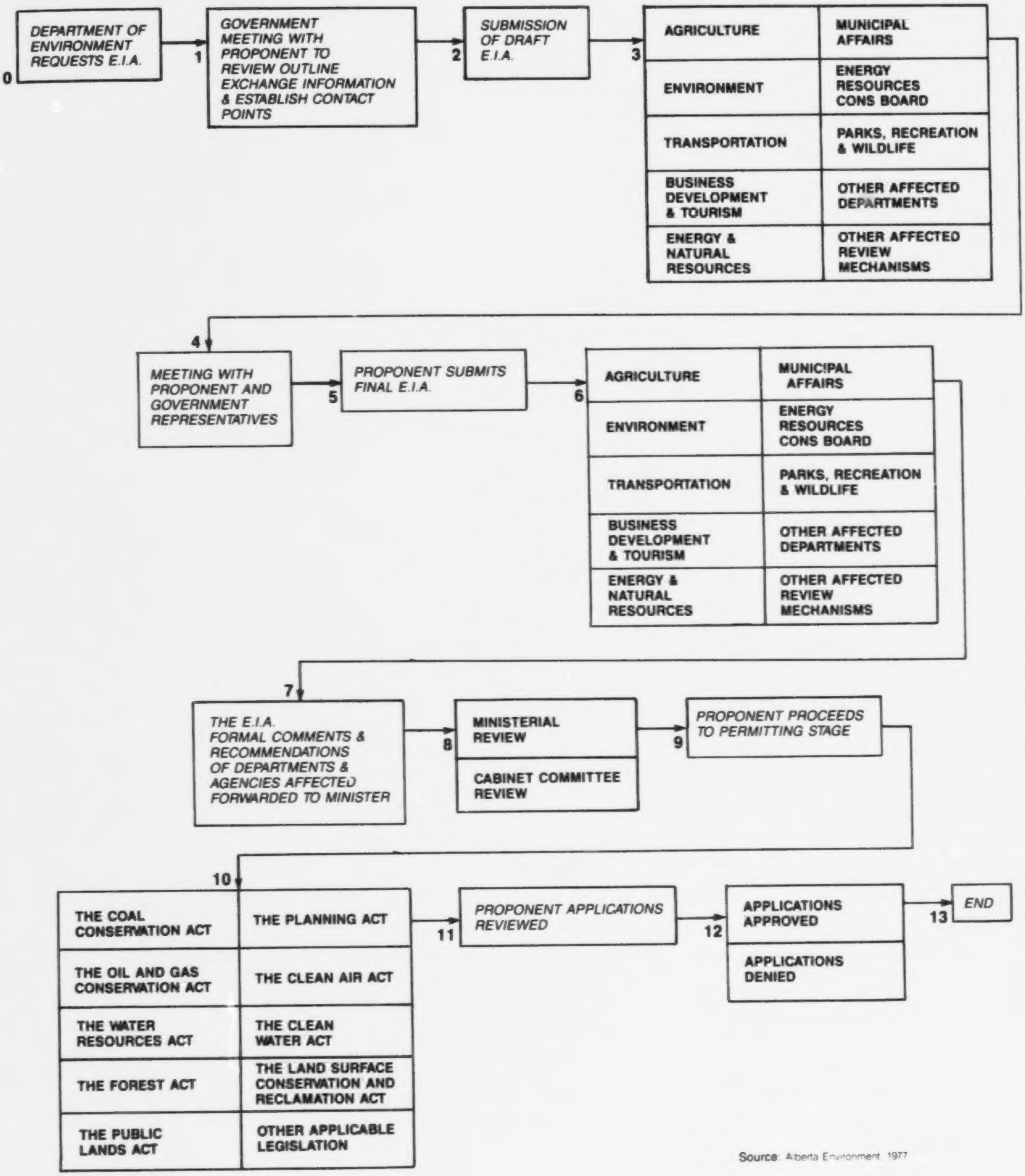
	Use of Specific Environmental Assessment Act or Section of an Act	Use of Cabinet Policy or Directive Under Authority of Other Environmental Legislation	Requirement That All New Mines Conduct an Environmental Impact Assessment**	Guidelines or Procedures Available	Requirement That Reclamation Plan Be Submitted As Part of the Environmental Impact Assessment	Economic and Social Impact Analysis is Required	Applies to Public or Private Developments
Federal		X*		X		X	both
Newfoundland	X*		X	X	X	X	both
Prince Edward Island		X*		X		X	public
Nova Scotia		X*	X	X	X		both
New Brunswick		X*		X		X	public
Québec	X*		X		X		both
Ontario	X*			X			public
Manitoba		X*	X	X	X		both
Saskatchewan	X*		X	X	X	X	both
Alberta	X*		X	X	X	X	both
British Columbia		X*	X	X	X	X	both

*Major method of implementing Environmental Impact Assessments.

**Type of assessment and degree of public access usually varies at the discretion of the Regulatory Agency. In some cases, expansions at existing mines may be required to conduct an Environmental Impact Assessment.

Source: See Appendix 11 for detailed aspects

FIGURE 11. **ALBERTA ENVIRONMENTAL IMPACT ASSESSMENT FLOW DIAGRAM**


0
DEPARTMENT OF ENVIRONMENT REQUESTS E.I.A.
1
GOVERNMENT MEETING WITH PROPONENT TO REVIEW OUTLINE EXCHANGE INFORMATION & ESTABLISH CONTACT POINTS
2
SUBMISSION OF DRAFT E.I.A.
3
AGRICULTURE
MUNICIPAL AFFAIRS
ENVIRONMENT
ENERGY RESOURCES CONS BOARD
TRANSPORTATION
PARKS, RECREATION & WILDLIFE
BUSINESS DEVELOPMENT & TOURISM
OTHER AFFECTED DEPARTMENTS
ENERGY & NATURAL RESOURCES
OTHER AFFECTED REVIEW MECHANISMS
4
MEETING WITH PROPONENT AND GOVERNMENT REPRESENTATIVES
5
PROPONENT SUBMITS FINAL E.I.A.
6
AGRICULTURE
MUNICIPAL AFFAIRS
ENVIRONMENT
ENERGY RESOURCES CONS BOARD
TRANSPORTATION
PARKS, RECREATION & WILDLIFE
BUSINESS DEVELOPMENT & TOURISM
OTHER AFFECTED DEPARTMENTS
ENERGY & NATURAL RESOURCES
OTHER AFFECTED REVIEW MECHANISMS
7
THE E.I.A. FORMAL COMMENTS & RECOMMENDATIONS OF DEPARTMENTS & AGENCIES AFFECTED FORWARDED TO MINISTER
8
MINISTERIAL REVIEW
CABINET COMMITTEE REVIEW
9
PROPONENT PROCEEDS TO PERMITTING STAGE
10
THE COAL CONSERVATION ACT
THE PLANNING ACT
THE OIL AND GAS CONSERVATION ACT
THE CLEAN AIR ACT
THE WATER RESOURCES ACT
THE CLEAN WATER ACT
THE FOREST ACT
THE LAND SURFACE CONSERVATION AND RECLAMATION ACT
THE PUBLIC LANDS ACT
OTHER APPLICABLE LEGISLATION
11
PROPONENT APPLICATIONS REVIEWED
12
APPLICATIONS APPROVED
APPLICATIONS DENIED
13
END

Source: Alberta Environment 1977

tion of the likely impact of the proposed development; a detailed assessment; a government and/or public review; and the decision to proceed or not to proceed. In most cases, provision is made for internal screening to eliminate small projects or projects with low environmental or socio-economic impacts from the entire multi-stage process. An example of the Alberta Environmental Impact Assessment flow diagram is given in Figure 11, as it applies to all developments under the authority of the Land Surface Conservation and Reclamation Act (1973). It is important to note that the E.I.A. procedure outlined in the flow diagram and its governing Act, cannot be taken in isolation. In Alberta additional formal requirements for the coordination of all proposals for major coal mine developments are contained in the Coal Development Policy for Alberta (Alberta, Dept. of Energy and Natural Resources, 1976). This is largely a reflection of the trend by provincial governments towards increased overall management of natural resources. Figure 12 outlines the overall procedures required and the stage at which reclamation plans must be submitted. (The procedure for designing, and obtaining approval of the reclamation plan has been dealt with earlier). Similar procedures have been developed in both Saskatchewan and British Columbia (British Columbia Environment and Land Use Committee, 1977; Saskatchewan Dept. of Mineral Resources, 1978).

The general procedure for obtaining approval for a new metal mine development in British Columbia is illustrated in Figure 13. The overall procedure is designed to be flexible, consisting of a two-stage process which can be modified by the Steering Committee when necessary. The Steering Committee utilizes several working committees that report directly to it, namely Minesite Advisory; Housing; Environmental Impact Assessment; and Economic Evaluation committees (*see* Figure 13 for description of their functions). The most important in terms of reclamation and environmental protection is the Minesite Advisory Committee. There is some federal involvement in the process as well. Representatives from the Environmental Protection Service (EPS) and Department of Fisheries and Oceans sit on some committees for new coal developments and the EPS contributes to reviews of submissions related to metal mine developments.

Figure 13 reveals that there are 4 procedures (A, B, C, and D) in the overall process, of which only one, the general procedure 'A' requires the full two-stage review process. The remaining three (B, D and C) terminate prior to the stage II report level. The four procedures of the review process are outlined below:

"PROCEDURE 'A' GENERAL

It is anticipated that most new mining operations will follow the two stage process outlined in Figure 1. The Stage I process requires the submission of a Stage I report, a general distribution and review. At the end of Stage I the Environment and Land Use Technical Committee (ELUTC) will determine if the full Stage II process is required if development information is not finalized or if mitigations are not resolved.

The Stage II procedure requires a Stage II report and an application for regulatory approvals. The Stage II report should provide detail on the final project design. This report will receive general distribution and review and is culminated by an approval of the project from the Environment and Land Use Committee (ELUC) composed of cabinet ministers.

PROCEDURE 'B' SMALL PROJECTS

Small projects with low environmental or social impact will be able to by-pass the review process following submission of a Stage I report and will be able to apply directly for regulatory approvals.

Applications for regulatory approval involve the normal inter-agency referral process.

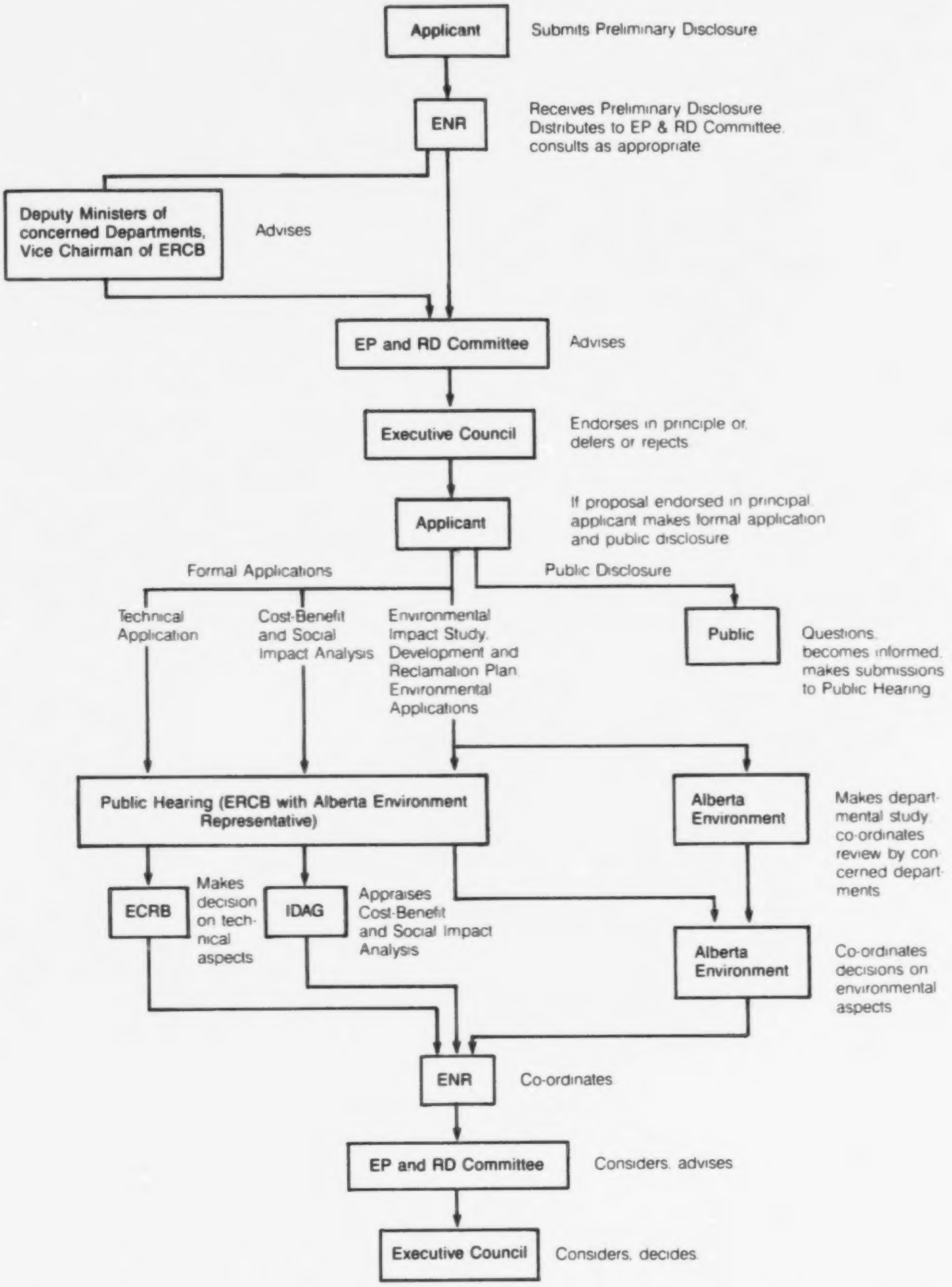
PROCEDURE 'C'

If, at the end of the Stage I review process, the project design is finalized and it is apparent that the proposal will have low environmental and social impact and there will be not economic cost to the Province, then the ELUTC may decide that a full Stage II report is unwarranted. It will recommend that the proponent apply directly for regulatory approvals.

PROCEDURE 'D'

If the project design is finalized by the end of the Stage I review process and, although all possible mitigations have been undertaken, there is still a moderate to high environmental or social impact or an economic cost to the Province then there would be little value to continuing the review procedure with a Stage II report.

FIGURE 12. **ALBERTA PROCEDURE FOR CO-ORDINATED CONSIDERATION OF PROPOSALS FOR MAJOR COAL DEVELOPMENTS**

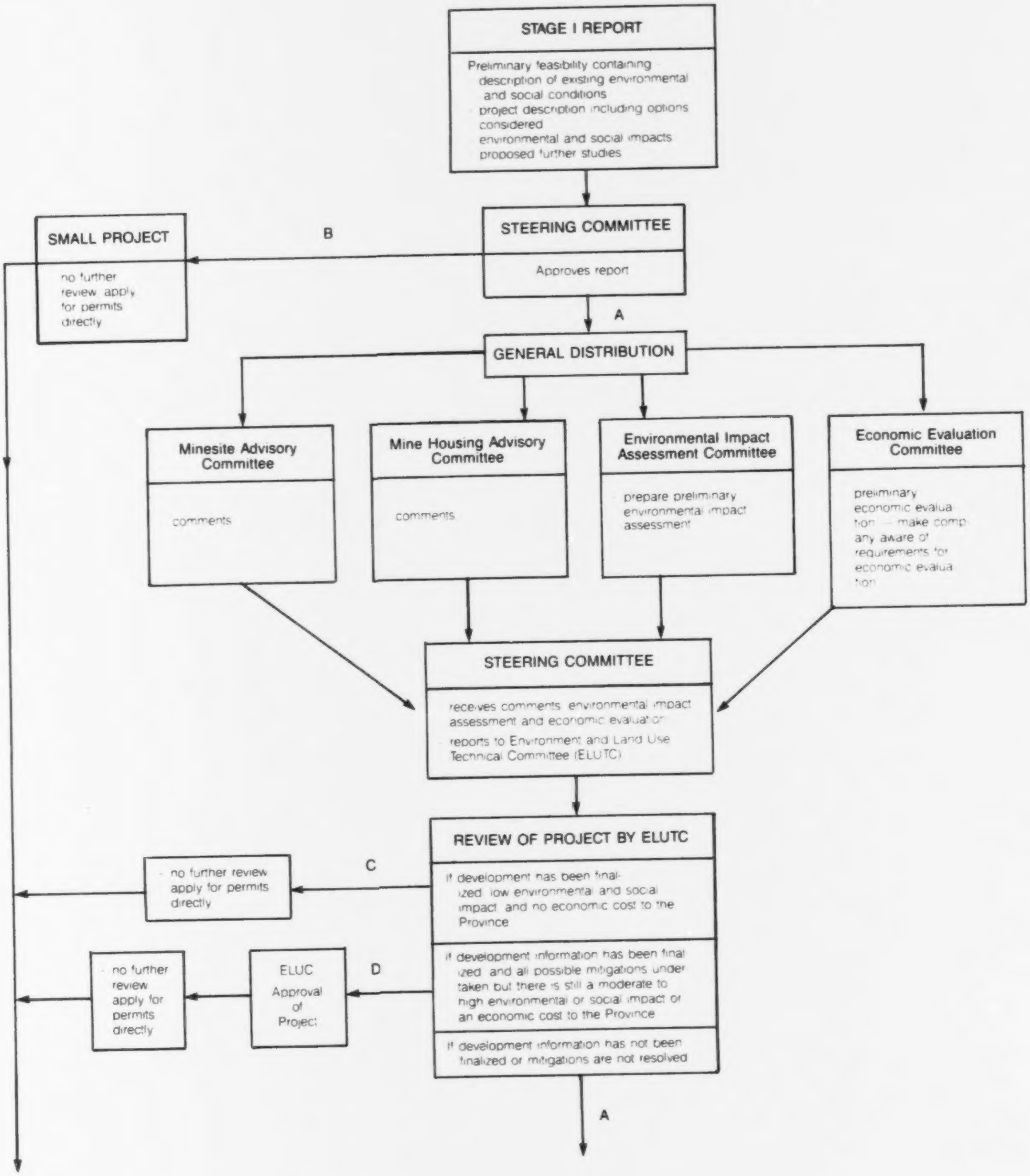

Applicant
Submits Preliminary Disclosure
ENR
Receives Preliminary Disclosure
Distributes to EP & RD Committee,
consults as appropriate
Deputy Ministers of
concerned Departments,
Vice Chairman of ERCB
Advises
EP and RD Committee
Advises
Executive Council
Endorses in principle or,
defers or rejects
Applicant
If proposal endorsed in principal,
applicant makes formal application
and public disclosure
Formal Applications
Public Disclosure
Technical
Application
Cost-Benefit
and Social
Impact Analysis
Environmental
Impact Study,
Development and
Reclamation Plan,
Environmental
Applications
Public
Questions,
becomes informed,
makes submissions
to Public Hearing
Public Hearing (ERCB with Alberta Environment
Representative)
Alberta
Environment
Makes depart-
mental study,
co-ordinates
review by con-
cerned depart-
ments
ECRB
Makes
decision
on tech-
nical
aspects
IDAG
Appraises
Cost-Benefit
and Social Impact
Analysis
Alberta
Environment
Co-ordinates
decisions on
environmental
aspects
ENR
Co-ordinates
EP and RD Committee
Considers, advises
Executive Council
Considers, decides

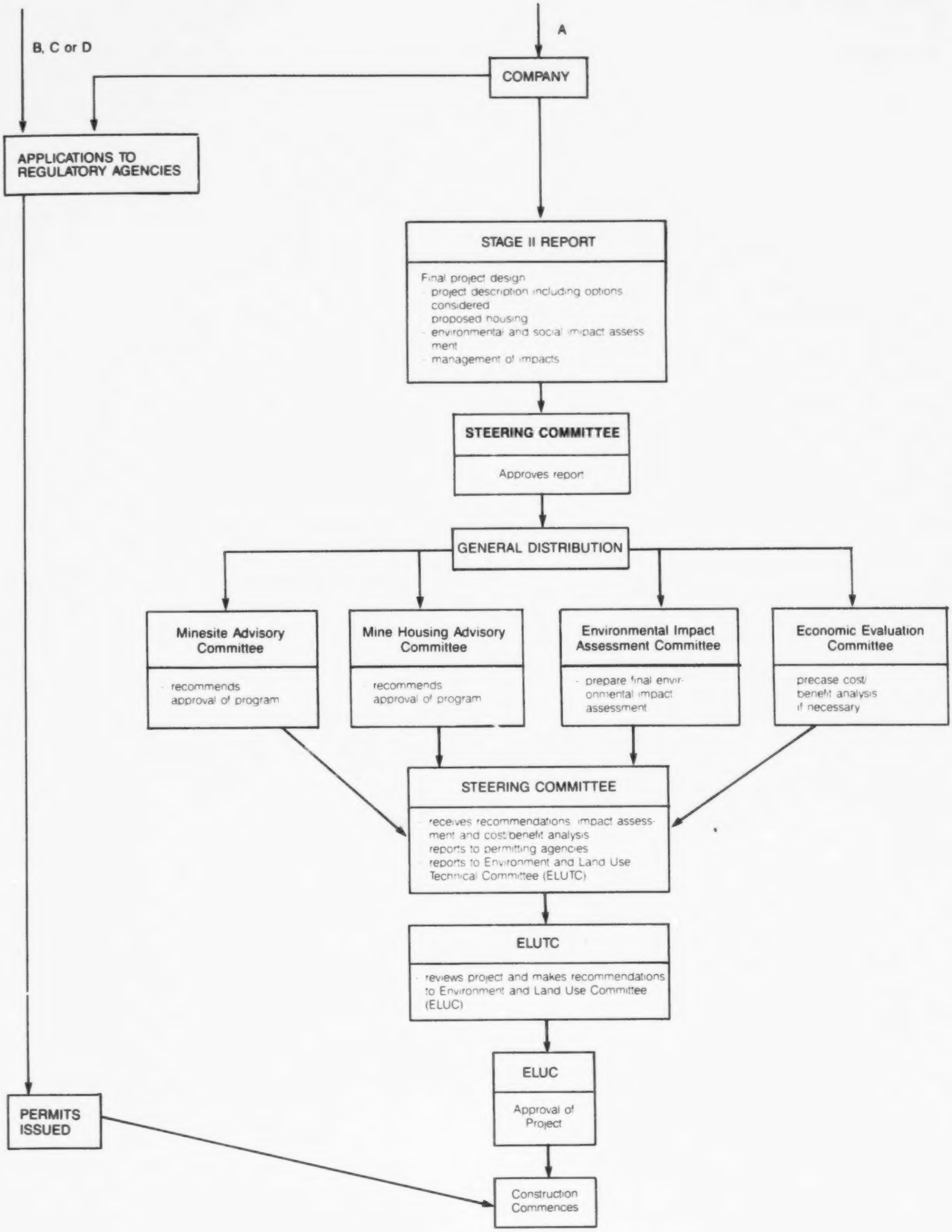
ABBREVIATIONS

EP and RD Committee	*Economic Planning and Resource Development Committee*
ENR	*Department of Energy and National Resources*
ERCB	*Energy Resources Conservation Board*
IDAG	*Interdepartmental-agency Group co-ordinated by the Department of Energy and Natural Resources*

Source: Alberta Department of Energy and Natural Resources, 1976

FIGURE 13. **BRITISH COLUMBIA: GENERAL PROCEDURE FOR OBTAINING APPROVAL FOR METAL MINE DEVELOPMENT**


STAGE I REPORT
Preliminary feasibility containing
description of existing environmental and social conditions
project description including options considered
environmental and social impacts
proposed further studies
STEERING COMMITTEE
Approves report
SMALL PROJECT
no further review apply for permits directly
B
A
GENERAL DISTRIBUTION
Minesite Advisory Committee
comments
Mine Housing Advisory Committee
comments
Environmental Impact Assessment Committee
prepare preliminary environmental impact assessment
Economic Evaluation Committee
preliminary economic evaluation — make company aware of requirements for economic evaluation
STEERING COMMITTEE
receives comments environmental impact assessment and economic evaluation
reports to Environment and Land Use Technical Committee (ELUTC)
REVIEW OF PROJECT BY ELUTC
If development has been finalized low environmental and social impact and no economic cost to the Province
If development information has been finalized and all possible mitigations undertaken but there is still a moderate to high environmental or social impact or an economic cost to the Province
If development information has not been finalized or mitigations are not resolved
C
no further review apply for permits directly
D
ELUC Approval of Project
no further review apply for permits directly
A


B, C or D
A
COMPANY
APPLICATIONS TO REGULATORY AGENCIES
STAGE II REPORT
Final project design
- project description including options considered
proposed housing
- environmental and social impact assessment
- management of impacts
STEERING COMMITTEE
Approves report
GENERAL DISTRIBUTION
Minesite Advisory Committee
- recommends approval of program
Mine Housing Advisory Committee
- recommends approval of program
Environmental Impact Assessment Committee
- prepare final environmental impact assessment
Economic Evaluation Committee
precase cost/benefit analysis if necessary
STEERING COMMITTEE
- receives recommendations, impact assessment and cost/benefit analysis
reports to permitting agencies
- reports to Environment and Land Use Technical Committee (ELUTC)
ELUTC
- reviews project and makes recommendations to Environment and Land Use Committee (ELUC)
ELUC
Approval of Project
PERMITS ISSUED
Construction Commences

Committees

Steering Committee
Is responsible for co-ordinating the review process. it is the main government contact for the mine and the primary vehicle for feedback from regulatory and non-regulatory government agencies and the public. It can appoint subcommittees. It is chaired by Ministry of Energy, Mines and Petroleum Resources, and is composed of one memeber each from the ELUC Secretariat and Ministries of Economic Development, Municipal Affairs and the Environment, plus an additional one from Energy, Mines and Petroleum Resouces.

Minesite Advisory Committee
The Committee is essentially the Advisory Committee on Reclamation that operates under the Mines Act on all applications for a surface work permit. Hence, it automatically reviews every mine proposal whether or not the mine is large enough to warrant a full review process.

The committee reviews all environmental protection and reclamation for proposed mine and access plans. It is composed of representatives of the ministries of Agriculture; Environment; Forests; Lands; Parks and Housing; and is chaired by Ministry of Energy, Mines and Petroleum Resources.

Mine Housing Advisory Committee
Reviews all associated developments concerned with providing living accommodations for mine employees.

Environmental Impact Assessment Committee
Reviews 'proponents' environmental impact assessment, if necessary, prepares or commissions an environmental impact (including socio-economic impacts) statement based upon the submissions from the proponent (and their consultant(s), and comments received from the government and the public. Committee is chaired my a member from the ELUC Secretariat, and composed of members from Energy, Mines and Petroleum Resources; Environment; Forestry; Lands; Parks and Housing as required.

Economic Evaluation Committee
This committee is responsible for making an economic evaluation of the project to decide if a cost/benefit analysis should be done. During Stage I, the committee makes the proponent aware of the data requirements for an economic evaluation. Where required, the committee will provide an or commission an economic cost/benefit analysis during Stage II.

In this case the ELUTC may request that the ELUC provide an overall approval of the project at this time subject to receipt of all necessary regulatory approvals." (British Columbia Environment and Land Use Committee, 1976).

In most proposed mine developments no single permit gives permission to operate at all levels. The multiplicity of responsible departments, each with their own vested authority, means that there will be numerous individual permits which must be obtained during the whole review and approval process.

A reclamation permit (or surface work permit in the case of British Columbia) will be only one of the many permits required, but it may be instrumental in the process of obtaining other permits (e.g. water pollution control permit). Hence, obtaining a reclamation permit can become a long and complicated process depending upon the ecological conditions and standards required by the jurisdiction involved.

The Environmental Impact Assessment system and requirements for reclamation are administered through a system of individually issued permits or licences. It provides for a high degree of discretionary power and control over the design and layout of new mine developments. The concept of the permit approval system relies heavily on guidelines and standards issued by the various departments and agencies, in order to provide site-to-site flexibility. It also means that just because an individual project is environmentally sound it does not automatically follow that other departments or agencies operating under other legislation will accept the proposal. The proponent of a new mine development must prove that the project satisfies all other requirements and standards even though environmental (and reclamation) approval has been granted. All of this takes time.

In most cases, should approval to proceed with a mineral development be given, it is normal to impose constraints designed to reduce the environmental and/or socio-economic impacts. Usually the limitations or added protection requirements result from shortcomings in design or from concerns expressed in public hearings and technological assessments of the development proposals. Although the added requirements may not be found in existing regulations or standards, the "Permit Approval System" now allows for flexibility on a site-to-site or project-to-project basis. Hence, final design and technological requirements for a mine site must wait for unforeseen changes that may emerge during the government assessment and public hearing stages of the formal evaluation procedure.

An example of this process is the conditions attached to the lease agreement between Amok Ltd. and the Government of Saskatchewan for the development of a new uranium mine signed September 29, 1978. At the time, neither the Saskatchewan government nor the Federal A.E.C.B. had published regulations covering reclamation and close-out operations for uranium mines. The land lease granted by the province required the lessee to agree to assume all liability for all damages of any nature whatsoever caused by the lessee. In addition the lessee agreed to meet all amendments made during the Cluff Lake Board of Inquiry. The main conditions in the lease agreement covering environmental and reclamation aspects are outlined below:

"10. ENVIRONMENT

(1) In this paragraph "Minister" includes such officials of the Department of Environment, Government of Saskatchewan as may be designated from time to time by the Minister.

(2) The Lessee agrees to implement, observe and comply with the following recommendations made by the Cluff Lake Board of Inquiry:

(a) reasonable sampling, analysis, and measurements, the nature and frequency of which shall be determined by the Minister of the effluent from the mill shall be made by the Lessee and the results thereof shall be directed to the Minister.

(b) The Lessee agrees to take all possible steps to ensure that the quantity of contaminants released into receiving streams and the atmosphere is as low as reasonably practicable and further agrees to comply with the effluent discharge standards that may be established by the Minister or any regulatory agency of the Government of Saskatchewan or Government of Canada and without limiting the generality of the foregoing the Lessee agrees to comply with effluent dishcarge standards respecting maximum concentrations of total (dissolved and suspended) thorium-230, thorium-232, radium-226 and lead-210 and of vanadium, molybdenum, magnesium calcium, sodium, sulphate and chloride.

(c) The Lessee agrees to prepare and submit for the approval of the Minister the results of additional baseline studies on air and water quality, plant and animal life, surface hydrology, and hydrogeology and such studies in the Snake Lake drainage basin shall be completed before designs and plans are finalized for the tailings pond construction and operation.

(d) Mine water from the "D" ore body shall be transferred from the pit to the mill or tailings pond pursuant to a plan approved by the Minister and shall not be diverted into Boulder Creek or elsewhere.

(e) Monitoring wells shall be drilled in the vicinity of the tailings pond, the number and exact location of which shall be approved by the Minister in reference to the baseline study to be completed with respect to the hydrogeology of the tailings pond area, for the purpose of detecting possible ground water contamination due to seepage. If the said water contamination fails to meet the requirements of federal and provincial effluent discharge standards the ground water shall be recycled to the tailings pond.

(f) The Lessee agrees to prepare and submit for the approval of the Minister a monitoring program to measure the environmental effects of the operation of the uranium mine and mill. The Minister

may require that this program include monitoring and measurement of contaminants related to air quality (particularly radon and its daughters), water quality, plant life, and animal life including fish and other aquatic organisms.

(g) Develop a contingency plan acceptable to Minister for handling and controlling accidental spills (whether on site or during transit to or from the leased land) of product or process materials of a hazardous or environmentally harmful nature.

11. ABANDONMENT

(1) The Lessee agrees to prepare and submit for the approval of the Minister or his designated official or agency a preliminary abandonment and reclamation plan respecting the tailings area together with a design for the proposed tailings pond prior to the commencement of site preparation or construction of the said tailings pond.

(2) During the term of this lease and prior to completion of the planned milling operations the Lessee shall prepare and submit for the approval of the Minister or his designated official or agency a final abandonment and reclamation plan for the tailings area and other areas directly affected by exploration or development and operation of the uranium mill. In the event the Lessee ceases milling operations or the lease is terminated by the Minister and no final abandonment and reclamation plan has been submitted by the Lessee and approved by the Minister, the Lessee agrees:

(a) To stabilize the tailings area to the satisfaction of the Minister and in particular to ensure that no radioactive dusts can be transported by wind and no leaching of contaminants (as defined in The Department of Environment Act) by ground or surface waters will occur;

(b) To ensure at the time of abandonment that no seepage of radioactive material is occurring from the concrete vaults used to store the radioactive waste from the "D" ore body, and

(c) To reclaim the surface of the leased lands to the satisfaction of the Minister.

23. COMPLIANCE WITH CERTAIN SELECTED STATUTES

Except where specifically otherwise provided in this agreement the Lessee agrees to perform, observe and comply with all laws in force in the Province of Saskatchewan including the provisions of The Provincial Lands Act, The Forest Act, The Game Act, The Occupational Health and Safety Act, The Fur Act, The Water Rights Act, The Mineral Resources Act, The Prairie and Forest Fires Act, The Department of the Environment Act, The Water Resources Management Act, The Litter Control Act, 1973, The Boiler and Pressure Vessel Act, 1977, The Electrical Inspection and Licensing Act, The Fire Prevention Act, The Gas Inspection and Licensing Act, The Passenger and Freight Elevator Act, The Radiation Health and Safety Act, and The Public Health Act, and to all the applicable provisions of the Regulations now in force or which may hereafter from time to time be made under the authority of the said Acts." (Lease agreement between Amok Ltd. (Saskatoon) and the Province of Saskatchewan, represented by the Minister of Northern Saskatchewan, dated September 29, 1978).

Environmental Guidelines for Surface Mining Operations were drafted by the Nova Scotia Department of Environment in 1978 under similar circumstances. A proposal to develop a large coal strip mine near Stellarton resulted in the guidelines being attached at the lease/permit stage due to the lack of existing legislation covering such an operation (*see* Appendix 4 for details of guidelines).

There has also been a growing need to be able to revise the conditions attached to a permit during the operational life of a mine, by both the proponent and regulating agencies. The life of a mine is frequently extended over several decades, during which time there can be significant unforeseen effects on the environment of the mining activities, as well as technological and economic changes which affect the methods and quality of mining, efficiency of milling, pollution control and reclamation requirements. Hence, permit renewals or denials have become the means of accommodating changes or enforcing the lack of compliance in all aspects of environmental control.

TRENDS IN REGULATORY REQUIREMENTS

GENERAL LEGISLATION

1. Reclamation requirements across Canada provide a wide range of enforcement concepts, ranging from those which spell out detailed policy and guidelines through those which present only general criteria to those in which the reclamation requirements are determined under licence/permit agreement or memorandum of understanding.

2. In general, stricter reclamation requirements especially those dealing with coal mines were introduced earlier and enforced to a greater extent. Either through a lack of legislation requiring reclamation or poor enforcement of its requirements, eastern provinces did not progress as rapidly as the western provinces. There are some exceptions; for example, the regulation of pits and quarries in Ontario. Most provinces are increasing environmental control and reclamation requirements at mine sites through the use of existing or new environmental assessment or broad environmental protection acts. Rarely is legislation retroactive with respect to reclamation requirements. New legislation does not apply to already abandoned mine sites.

3. Federally, there is still no legislative requirement for reclamation to be conducted at mine sites north of 60°, nor elsewhere with the exception of special requirements for uranium mines under AECB jurisdiction, attached to permits to operate. Any mine on federal lands within provincial boundaries follows provincial reclamation requirements.

4. There is an increased use of specific sector regulatory mechanisms to deal with unique conditions, rather than attempting to cover all aspects of the mining industry under one act or set of regulations. The earliest specialized requirements were for "coal" and "aggregate" operations owing to their more obvious surface disturbances. Other separate regulatory mechanisms have been established for metallic, uranium, oil sands and exploration activities.

5. Since by the end of the 1970s there has been a greater use of guideline mechanisms for reclamation rather than regulations applied by sector and/or stage of mine development. Emphasis is likely to remain on standards, with guidelines indicating how best these can be achieved. Much of this has been prompted by the need for greater flexibility and more on-site decisions regarding reclamation plans by mine operators. This was inevitable given the wide range of ecological conditions within each province, not to mention across Canada as a whole. This coupled with the unique characteristics of different mining operations made it impossible to standardize reclamation regulations or criteria except on the broadest principles. Flexible guidelines allow for advances in research to be integrated on an ongoing basis, as well as the advantage of including accumulated knowledge from applied practice from a wider variety of locations.

6. Failure of early reclamation legislation to provide adequate controls on both private and crown lands is being reassessed by most provinces. In most cases the trend has been to make reclamation requirements applicable to all lands, regardless of ownership, either through amendments to existing legislation or by drafting new regulations.

7. At the local municipal or regional government level zoning restrictions and by-laws requiring reclamation within municipal boundaries are playing an increasingly important role in the aggregate industry. In some jurisdictions the hurdle in obtaining a "licence or permit" to operate consists in meeting local government requirements and approval. In some cases, municipal reclamation requirements are the only ones in force due to tenure and jurisdictional discrepancies. Rarely are municipal reclamation requirements less demanding than those of provincial statutes.

8. Legislation currently being enacted across Canada generally does little to resolve the problems of land left derelict and abandoned in the past, as a consequence of mining activities. Only the province of Ontario has established a provincial reclamation fund for such purposes, Alberta uses the Heritage Fund to clean up abandoned sites.

MINE DEVELOPMENT AND PLANNING

1. There has been an increase in legislation and policies directed towards resource management and land use planning. Much of this is concerned with restricting access zoning, and controlling the development of specific commodities. This reflects a growing public concern that development should pay its own way (that mining should internalize its costs) and that development of limited resources

should be well planned with adequate environmental protection. An important trend in the overall resource management process is the heightened concern over the increased degradation of the renewable resource base. Mine developments will have to pay much more attention to it.

2. The most widely adopted means of obtaining comprehensive multi-disciplinary control of new mine developments has been the adoption of Environmental Impact Assessment procedures either through definitive acts and regulations or through the introduction of policy statements issued under the authority of other environmental acts. Paralleling this development is the introduction of socio-economic impact assessment requirements in more than half the provinces. Assessment requirements have led to the rise in preplanning of environmental protection nuances and reclamation procedures for all new mine developments or expansions to existing mines. The use of E.I.A. procedures is here to stay, the only question is to what extent are they uniformly applied.

3. The means of enforcing E.I.A. procedures and the implementation of reclamation requirements is through the use of "conditions of permit approval" on a site by site basis. The major means by which reclamation will be implemented will be through permit negotiations and the permit renewal system.

4. The trend in the permits system has been to introduce Reclamation Review Committees with representatives from a wide number of involved departments and agencies (particularly in western Canada). Similarly, a number of elaborate co-ordinating or referral systems for "permit" approval have been established. In most cases, the use of the Environment Department or a semi-independent agency as the central co-ordinator and major inspector of reclamation activities is the norm, although there are exceptions. However, line departments (e.g. Mines and Energy, or Natural Resources) have maintained their former jurisdictions and traditional functions under older acts. This means that more than one licence, lease or permit will often be required in the mine approval process.

5. Throughout Canada final appeal on E.I.A. decisions and reclamation plan requirements lies with the responsible department with final appeal to the Minister responsible. Hence, there is a great deal of ministerial discretion involved in the entire process, in order to deal with the uniqueness of each new mine proposal.

But, whatever the differences in legislative or administrative approach, the concept of "design for abandonment" is finding considerable support. The E.I.A. process and the individual "permitting" system appear to be the most important instruments in its adoption.

ENFORCEMENT MECHANISMS

1. Regulations governing land reclamation have grown steadily more stringent over the years. After a decade of legislative change, two basic premises apply to new mine developments. First, mines should be prepared to accept constraints or conditions being attached to permits as a condition of approval. Secondly, they should be prepared for modifications in the conditions of a permit during the life of a mine operation. The requests for changes may come from a wide range of sources.

2. The trend in current legislation is to use one or more of the following enforcement mechanisms to ensure that reclamation requirements are met:

   (i) licence/permit denial

   (ii) posting bonds or security deposits

   (iii) fines or penalties

   (iv) filing reclamation plans

   (v) field inspection by regulatory agencies

RECLAMATION REQUIREMENTS

Actual requirements can vary dramatically from site to site and province to province. Not all the requirements below will be necessary at many sites. The most common requirements are:

(i) proponent pays the costs;

(ii) pre-operational development of reclamation plans;

(iii) increased requirement for a designated after use;

(iv) concurrent or sequential reclamation be conducted where possible during mine operations (e.g. coal, sand and gravel);

(v) reclamation research be commenced immediately to find solutions to problem areas;

(vi) reclamation process itself include;
  - stockpiling of topsoil and subsoil
  - site preparation (grading, contouring, backfilling)
  - minimum slope angles;
  - stabilization and erosion control
  - re-establishment of proper drainage conditions
  - revegetation
  - soil ameliorization
  - maintenance and follow-up monitoring

(vii) additional specialized requirements for designated land uses; for example, crop production or residential housing.

Reclaimed coal mine overburden spoils, B.C. Coal Ltd., Sparwood, British Columbia
I.B. Marshall, Environment Canada

Chapter Three

RECLAMATION PROGRAMS IN CANADA

INTRODUCTION

In the past decade there has been a considerable, but uneven increase both in interest and effort by different levels of government towards land reclamation in the mining industry. Previously, most of the effort was directed towards the improvement of air and water quality at mine sites. Although this still remains the number one priority of all government environmental protection programs, an increasing awareness of the importance of reclamation in improving air and water quality at mine sites has developed.

Reclamation can play an important role in controlling contamination caused by wind and water erosion from disturbed lands and waste dumps. Prior to 1970, reclamation had not been a government or industry priority in Canada. The information presented in this chapter will show that there has been a considerable increase in reclamation activity, arising out of the regulatory requirements introduced by the provinces during the past decade. However, there has not been a uniform level of progress throughout all provinces and territories.

Much of the data presented in this chapter is from the "Inventory of Reclamation Projects" compiled as background material for this study (Appendix 12).[9] It was not possible to obtain a complete list of reclamation projects conducted during the past decade, nor was it possible to attempt a systematic review of all those individuals or agencies involved in the extremely wide number of disciplines and subjects associated with reclamation today. However, significant data were collected to present a good indication of the growth and current direction of reclamation activities in Canada. The primary objective was to determine the extent of federal, provincial and university involvement in the field. The study did not attempt to review all private company research and consulting company involvement, but included those projects which involved cooperation with government or university departments and agencies. Individual projects listed include the following information: initiating or funding agency; principal researcher and/or consultant; project outlines; type of activity; duration; and cooperative agency or industry.

A second "Inventory of Reclamation Activities at Canadian Mine Sites" is also included (*see* Appendix 16). It is more limited in scope, due to the vast number of former and currently operating mines. Due to the large numbers involved, it was not possible to include operating companies associated with the mineral aggregate industry (Marshall, 1982). Therefore this inventory was limited to the name of the operating company, mine site, cooperating agencies or consultant used, type of activity and approximate year in which reclamation activities commenced. Most of the material associated with the second inventory will be dealt with in the following chapter.

NATIONAL OVERVIEW

A total of 352 projects were identified as having government or university involvement, either as direct involvement in research or as the coordinating or funding agency. In some cases, the project may have had several additional sub-projects associated with it. Table 4 provides a breakdown of the projects according

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[9] The inventory did not include all of the individual reclamation projects coordinated by the Alberta Department of Environment. Since 1973 hundreds of coal mines, sewage lagoons, landfill sites, sand and gravel pits, garbage pits, seismic lines and access roads abandoned prior to the enactment of the Alberta Land Surface Conservation and Reclamation Act in 1973 have been reclaimed using the Alberta Heritage funds. Only those reclamation projects which had associated field research and testing programs or operational cleanup of mining related activities were included in the inventory.
Surveys of reclamation activities in Alberta have been conducted by the Alberta Revegetation Research Co-ordinating Committee in 1976, and by its successor, the Reclamation Research Technical Advisory Committee in 1980 (Sims *et al.*, 1977, Walker and Rothwell, 1981). Both surveys serve as a model for compiling the inventory in this report as well as a major source of information.

Underground head frame and tailings pond, Fecunis mine, Sudbury, Ontario
I.B. Marshall, Environment Canada

TABLE 4. SUMMARY OF FEDERAL AND PROVINCIAL RECLAMATION PROJECTS IN CANADA

(A) According to Subject and Period of Commencement

SUBJECT	PERIOD OF COMMENCEMENT BEFORE 1970	1970-74	1975+	TOTAL
Coal	4	30	70	**104**
Metals		33	31	**64**
Non-Metallic		2	33	**35**
Uranium		5	5	**10**
Oil Sands		7	18	**25**
Disturbances[a]	1	24	57	**82**
Asbestos		1		**1**
General: Canada Wide Reviews, Bibliographies, Planning manuals		4	27	**31**
TOTAL	**5**	**106**	**241**	**352**

(B) According to Location and Period of Commencement

PROVINCE	PERIOD OF COMMENCEMENT BEFORE 1970	1970-74	1975+	TOTAL
Atlantic Provinces	1	10	8	**19**
Quebec		6	4	**10**
Ontario	1	22	42	**65**
Manitoba/ Saskatchewan	1	4	7	**13**
Alberta	1	34	141	**176**
British Columbia	1	9	20	**30**
Yukon & N.W.T.		21	18	**39**
TOTAL	**5**	**106**	**241**	**352**

[a] - Includes revegetation studies applicable to all types of disturbances.

See Appendix 13 and 14 for further details.

to subject and period of commencement, and to location and period of commencement. Five projects were identified as starting before 1970, 106 between 1970-74 and a further 241 since 1975. Records on activities prior to 1970 often are non-existent or incomplete, so the figure representing this period is the least accurate. However, it is evident that there has been a dramatic increase in the level of reclamation activity. In terms of regional distribution 67 percent of the projects took place in the four western provinces. Fifty percent of all projects were conducted in Alberta, followed by 19 percent in Ontario. Almost 50 percent of the projects in Alberta dealt with coal mine operations, and 40 percent of those in Ontario were concerned with metallic and uranium mines, proportions not out of line with the dominance of these mining sectors in their respective provinces. The Atlantic provinces, Quebec, and Manitoba/Saskatchewan regions combined, accounted for less than 15 percent of the total projects. In terms of the purpose of the reclamation projects, almost 30 percent were associated with coal operations, 23 percent with revegetation studies applicable to all types of disturbances and 18 percent with metallic mines.

The federal government was involved in 128 projects, 30 of which were carried out by federal personnel alone. The remainder were either funded or coordinated by the federal government in cooperation with other provincial agencies, or jointly funded with the provinces, private companies or universities. Similarly, provincial governments were involved in 191 projects, 149 of which were funded solely by the provinces. University researchers were involved in 111 of the projects inventoried, however, only 16 were based on university generated funding (*see* Appendix 12 for details). There was a high degree of university reliance on federal and provincial funding agencies. In addition, there is a growing trend towards direct university involvement with mining companies in joint research programs or the use of university consultants by mining companies.

Although the federal government was involved in some 128 projects, almost 40 percent involved research that was not specifically designed to deal with mining wastes, however, the knowledge gained from these projects could be applied to reclaiming mining disturbances. This is particularly true of federal projects con-

TABLE 5. **SUMMARY OF RECLAMATION PROJECTS IN CANADA:**
Level of Research Involvement

	LEVEL OF RESEARCH INVOLVEMENT*				
PROVINCE	**1**	**2**	**3**	**4**	**TOTAL NO. PROJECTS**
Atlantic Provinces	8	9	2	–	19
Quebec	1	7	2	–	10
Ontario	19	31	13	2	65
Manitoba/Saskatchewan	5	6	1	1	13
Alberta	10	103	31	32	176
British Columbia	4	23	3	–	30
Yukon/N.W.T.	–	20	19	–	39
CANADA	**47**	**199**	**71**	**35**	**352**

*Level of Research Involvement:

1. Actual Site Reclamation Combined with Research Program.
2. Directly Related Research Designed to Reclaim Mining Disturbances.
3. Indirectly Related Research: Research results that could be applied to reclaim various land disturbances.
4. Site Reclamation Only.

Source: Derived from Inventory of Mining Reclamation Research Projects in Canada. Appendix 12

TABLE 6. SUMMARY OF RECLAMATION PROJECTS IN CANADA:
Type of Research Activities Undertaken

	TYPE OF RESEARCH ACTIVITY*					
PROVINCE/TERRITORY	Li	Lab	Gse	Fld	Rcl	TOTAL NO. PROJECTS
Atlantic Provinces	6	13	–	14	7	19
Quebec	2	9	1	10	2	10
Ontario	22	39	4	55	22	65
Manitoba/Saskatchewan	5	10	–	11	4	13
Alberta	64	74	13	107	47	176
British Columbia	9	20	1	26	4	30
Yukon/N.W.T.	6	34	–	35	–	39
CANADA	**114**	**199**	**19**	**256**	**86**	**352**

*Type of Activity: more than one type of activity may be involved in a single project.

Li - Literature review, bibliographies, reclamation planning.
Lab - Laboratory based research
Gse - Greenhouse experiments
Fld - Field test trials, (biophysical inventories or environmental impact assessment).
Rcl - Actual site reclamation.

Source: Derived from Inventory of Mining Reclamation Research Projects in Canada. Appendix 12

ducted in the Yukon and Northwest Territories, where 75 percent of the work dealt with general land disturbances, many associated with pipeline projects. Provincially, only 10 percent of 224 projects fell into this category. Table 5 summarizes the level of research involvement by province.

The type of activity conducted at each project is summarized in Table 6. However, more than one type of activity can be involved in a single project, the most common combination being laboratory and field test trials. Almost three-quarters of the projects involved field test trials, and one-quarter involved actual site reclamation. Less than one percent of the projects conducted greenhouse experiments. Because of what has been labelled "uniqueness" of each mining situation, a considerable number of literature reviews were conducted (a third of all projects), only a dozen or so of which resulted in published bibliographies or planning manuals.

The high percentage of projects associated with the coal industry is largely a reflection of the early legislation passed in British Columbia (1968) and Alberta (1973) requiring reclamation, as well as more recent measures in Saskatchewan, New Brunswick and Nova Scotia that promote reclamation through the use of new legislation and environmental impact assessment requirements. All currently operating coal mines are actively involved in reclamation work. Overall, it is evident that there is a high degree of concentration in the level of reclamation activity in terms of location and type of mine.

FEDERAL PROGRAMS

The federal government has not developed an overall policy or program dealing with land reclamation. This is not surprising with land located within the provinces, where the federal government does not have any jurisdiction in the field of land management or land use, but it does not account for the vast amount of Crown land under its jurisdiction in the Yukon and Northwest Territories. Almost all involvement to date has been in response to formal requests for assistance on specific problems, joint federal-provincial initiatives, or *ad hoc* advice that arises in the regulatory process dealing with air and water pollution control. Two other exceptions are the federal jurisdiction over all uranium mining activities, and those mines in which the federal government has an equity.

Only five federal departments have been involved in some aspect of land reclamation over the past decade: Environment; Energy, Mines and Resources; Indian and Northern Affairs; Agriculture; and Public Works. Two federal Crown corporations have been involved in funding research in a limited way: the Atomic Energy Control Board, and the Natural Sciences and Engineering Research Council (formerly, under the jurisdiction of the National Research Council). The level of involvement by departments and Crown corporations is summarized in Table 7. Almost two-thirds of the projects involved direct related research designed to reclaim mining disturbances or operational site reclamation. Most of the remainder were associated with reclaiming disturbances associated with transportation corridors and pipeline right-of-ways.

ENVIRONMENT

The Department of Environment (DOE) does not have an overall integrated program for dealing with land reclamation, but has become involved in a number of projects through joint funding or contracting directly for specific needs associated with its regulatory role in air and water pollution control. One of the largest examples of this involvement was the Alberta Oil Sands Environmental Research Program (AOSERP), jointly funded with the province of Alberta between 1975-80. Part of the research on this project included programs to identify reclamation methods which will be useful in restoring productivity in disturbed areas.

TABLE 7. **SUMMARY OF RECLAMATION PROJECTS IN CANADA:**

Federal Level of Research Involvement*

	LEVEL OF RESEARCH INVOLVEMENT*					
PROVINCE	1	2	3	4	**TOTAL NO. PROJECTS**	% federal involvement
Atlantic Provinces	3	6	2	–	19	58
Quebec	–	6	2	–	10	80
Ontario	2	14	11	–	65	31
Manitoba/Saskatchewan	1	3	1	–	13	31
Alberta	2	20	10	1	176	19
British Columbia	–	5	3	–	30	26
Yukon/N.W.T.	–	17	19	–	39	92
CANADA	**8**	**71**	**48**	**1**	**352**	
% federal involvement	6	55	37.5			

***Level of Research Involvement:**

1. Actual Site Reclamation Combined with Research Program.

2. Directly Related Research Designed to Reclaim Mining Disturbances.

3. Indirectly Related Research: Research results that could be applied to reclaim various land disturbances.

4. Site Reclamation Only.

Source: Derived from Inventory of Mining Reclamation Research Projects in Canada Appendix 12

The Environmental Protection Service, while primarily concerned with the quality of air and water, and the inspection, monitoring and drafting of regulations, has contracted a number of studies to be done, pertaining to tailings reclamation usually associated with uranium and sulphide ore mines. In addition it has provided advice and guidance on establishing reclamation programs, and used its laboratories for testing samples.

The Canadian Forestry Service has the longest history of involvement in reclamation research within the department. The Northern Forest Research Centre in Edmonton was involved in the early development of revegetation techniques and new species suitable for growth on disturbed lands (especially mine wastes). However, due to changes in priorities of the Canadian Forestry Service, by the mid-1970s this program had been reduced in size and emphasis to a basic ***ad hoc*** advisory role. Some of this research was transferred to the growing provincial research program or to private industry.[10]

Parks Canada has contracted out several studies directed towards the reclamation of a wide range of land disturbances within park boundaries, including sand and gravel pits used for highway construction. Projects have included the preparation of reclamation guidelines and manuals, as well as field tests to develop suitable species of grass, shrubs and trees for reclamation of disturbances in sub-alpine and alpine conditions. Most of the projects are conducted by the western regional office. Parks Canada occupies a unique position in that it has an ongoing operational role of land management.

INDIAN AND NORTHERN AFFAIRS

The rapid expansion of exploration activities north of 60· latitude in the late 1960s and early 1970s led to the introduction of the "Land Use Permit Review Process, and Inspection Procedures", to control the effects of resource development under the Territorial Lands Act. Although the Department of Indian and Northern Affairs (DINA) established a mechanism for screening and inspecting land use activities, it lacked the necessary environmental baseline data to make decisions regarding the effects of certain land use activities and to identify or recommend the necessary reclamation procedures.

In order to alleviate this problem the department, through the Arctic Land Use Research Program, has initiated substantial inventory and research studies utilizing other departmental, university and private consulting expertise to complement the objectives of the Territorial Lands Act and Regulations. An advisory committee consisting of representatives from four industries and four universities as well as the chief of the Environmental Studies Division reviews and provides guidance on the choice of projects.

Most of the research is divided into one of two programs; the first deals with the collection of environmental baseline data on the natural conditions of the arctic; while the second monitors the effects of certain land use activities on the land and the anticipated impact of these activities. Some of the studies have examined remedial measures and reclamation techniques, particularly in the field of revegetation, although most have concentrated on the effect of mine tailings on the environment or emphasized mine waste containment and water quality. Only ten of thirty mine projects identified north of 60° in the inventory, actually took place at mine sites. Almost all the remaining projects were related to the revegetation of surface disturbances caused by exploration, and the construction of pipelines and roads.

AGRICULTURE

The Department of Agriculture has become involved in land reclamation primarily with regard to those disturbances which affect existing or potential agricultural land. In the past, the department concentrated on the reclamation of naturally degraded soils, such as solonetzic or arid soils, and the control of erosion and water problems under the Prairie Rehabilitation Development Act and the later Agricultural Rehabilitation Development Act. The department has recently completed an assessment of the location and extent of degradation on agricultural lands, including those attributable to mining – particularly coal, sand and gravel (Coote ***et al.***, 1981).

The department has become more involved in land degradation problems related to the effects of mineral and energy production, where its specialists have been studying the effects of uranium acid mine tailings, and potash dust on the environment (Ballantyne, 1974, 1978; Ivarson, 1982; MacLean, 1976). Another focus of attention has been the effects of the construction of underground oil pipelines on crop yields (Culley ***et al.***, 1981). Almost all these research investigations have been cooperative projects among federal, provincial and university personnel in the particular province in which the disturbance is located. Most of them have been initiated by requests from either the National Energy Board, the industry concerned or internal agriculture concern. Recently, however, concern about the increased degradation of the agricultural land base has led to the initiation of programs for preventing further degradation and developing techniques to reclaim soils or mitigate adverse impacts. Most of these activities are not directly related to mine disturbances. Some of the research, however, particularly that on soil-water relationships and the movement of toxic compounds through soil mediums, may be of considerable use in reconstructing soil profiles.

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[10] The Newfoundland Forest Research Centre did become involved in active reclamation field tests at the Buchans mine about the same time (Sidhu, 1979).

PUBLIC WORKS

In the fall of 1976 the Department of Public Works set up the Environmental Impact and Assessment Review Division in response to their participation on the Interdepartmental Committee on the Environment and the demand for the EARP process to be undertaken on all future projects with federal involvement. The department is only involved in specific sites in which federal government activities have disturbed land and reclamation is required. In the past, this involvement has largely been in cooperation with Parks Canada and DINA, particularly with regard to highway construction. The department uses private sector consultants to conduct specific background studies on reclamation requirements and to carry out actual on site reclamation when required.

NATIONAL ENERGY BOARD

The board is involved in the surveillance of energy related activities which fall under its jurisdiction, namely international and inter-provincial transport of energy commodities. The board does not have the staff or research facilities to undertake reclamation work and it can only make recommendations to other federal agencies regarding problems in land reclamation faced by those companies which fall under its jurisdiction. It was under these circumstances that the Canada Agriculture Land Resource Research Institute undertook research into the effects of the new eastern pipelines on agricultural land. The board is responsible for initiating Environmental Assessment Review programs on all proposed pipelines under its direct jurisdiction, especially those in the north, which are conducted in cooperation with DINA and DOE.

ATOMIC ENERGY CONTROL BOARD

The Board is one of the few federal agencies directly involved with mining, especially uranium mines. In 1976, it formed an Advisory Panel on Tailings to consider the long-term, post-operational integrity of present and proposed methods for the management of uranium mill tailings. Membership on the panel includes representatives from the federal, provincial and the non-governmental sectors. Active research projects have involved the following participants: Denison Mines; Rio Algom Ltd.; Eldorado Nuclear Ltd; Energy, Mines and Resources; Canada Centre for Inland Waters and Environmental Protection Service, Environment Canada; the Universities of Carleton, Calgary and Toronto; and the Ontario Ministry of Environment.

Earlier research on finding a suitable method of revegetating uranium tailings is declining in favour of finding solutions to water pollution problems during the operative and post-operative periods. The board continues to support research at mine sites in the Elliot Lake and Uranium City regions, usually through recommendations of its Advisory Committee and Environmental Protection Service experts (Dept. of Energy, Mines and Resources, 1981).

ENERGY, MINES AND RESOURCES

Reclamation related activities were initiated under the old Mines Branch and what is now the Canada Centre for Mineral and Energy Technology (CANMET). In-house research and contract funding to universities was begun in 1970 to find a method of stabilizing and reclaiming (through revegetation techniques) acid mine tailings in the Sudbury area and the uranium tailings at Elliot Lake. Research on reclaiming uranium tailings by revegetation is the longest standing project that the department has conducted with its own personnel. The project has been considerably reduced in size in recent years, reflecting the change in direction of research away from revegetation as a solution to the problem. Funding support has been expanded to deal with more serious subsurface hydrology, and geochemical problems. Expenditures on tailings management by CANMET to the end of 1980 have been in excess of $3 million.

In 1974, CANMET initiated a three year Cooperative Revegetation, Project involving the federal government, industry, universities and consulting companies in all provinces and territories. The project was designed to evaluate the physical and chemical properties of mine wastes at 50 different mine sites in order to determine the major factors that would inhibit the revegetation of the mine wastes. The results of the various studies were summarized and published as supplements to a larger pit slope manual (Murray, 1977**a** and **b**). No further projects related to reclamation followed this project.

The Terrain Science Division, Geological Survey of Canada has been involved in studies concerned with the stability of coal wastes dumps from open-pit mines in the Rocky Mountains (Harrison, 1974**a**, 1974**b**, 1977).

The major initiative of the 1980s has been the announcement of a five-year federal uranium tailings research program by the Minister of State for Mines (Dept. of Energy, Mines and Resources, 1982). The $9.5 million program, aimed at speeding the development of technology to reduce the harmful effects of waste material from uranium mining and milling, stems from the recommendations of the National Technical Planning Group on Uranium Tailings Research, established in 1980 by the Canada Centre for Mining and Energy Technology (Dept. of Energy, Mines and Resources, 1982).

A National Tailings Program Office (NTPO) is to be established in Ottawa, and managed by a program director responsible to a board of directors made up from the funding agencies, regulatory bodies and the producing companies. The tailings program will consist of three subprograms:

- a mathematical and computer modelling activity, to facilitate the prediction of long-term contaminant release and dispersion;
- a field measurement project, focusing o three specific sites, to measure contaminant levels and verify mathematical models; and
- a disposal-technologies project to develop alternate long-term disposal techniques.

One of the program objectives is to prepare a preliminary manual for outlining points to be considered in close-out actions. The program was originally designed to be funded by $18.5 million, with the provinces of Ontario and Saskatchewan participating, but they have not as yet, confirmed their intention to join.

NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL

The council is responsible for funding research in the universities and other centres of higher learning through its scholarships and grants program. This was formerly under the jurisdiction of the National Research Council. The Council(s) has(have) awarded funds to

Coal strip mining, Estevan, Saskatchewan
NFB — Phototheque — ONF, Crombie McNeill

TABLE 8. SUMMARY OF RECLAMATION PROJECTS IN CANADA:

Provincial Level of Research Involvement

	LEVEL OF RESEARCH INVOLVEMENT*				
PROVINCE	**1**	**2**	**3**	**4**	**TOTAL NO. PROJECTS**
Atlantic Provinces	6	4	–	–	10
Quebec	–	–	–	–	–
Ontario	10	14	2	2	28
Manitoba/Saskatchewan	4	2	–	1	7
Alberta	8	75	18	31	132
British Columbia	3	11	–	–	14
Yukon/N.W.T.	–	–	–	–	–
CANADA	31	106	20	34	191

*Level of Research Involvement:

1. Actual Site Reclamation Combined with Research Program.
2. Directly Related Research Designed to Reclaim Mining Disturbances.
3. Indirectly Related Research: Research results that could be applied to reclaim various land disturbances.
4. Site Reclamation Only.

Source: Derived from Inventory of Mining Reclamation Research Projects in Canada. Appendix 12

support reclamation related research proposals by university staff, but the number of awards have never been more than 1 or 2 a year, and it is not part of any formal program.

PROVINCIAL PROGRAMS

About 55 percent of the reclamation projects identified in the inventory were supported by provincial funding or manpower. The most striking aspect of the provincial programs is that almost 70 percent of the projects have taken place in Alberta. Neither research nor operational projects were identified for the provinces of Newfoundland and Quebec, and only operational projects were identified for Prince Edward Island. A very small percentage of the projects (10 percent) was not directly related to reclaiming mine disturbances (Table 8).

ATLANTIC PROVINCES

Due to the late introduction of regulations on reclamation in all the Atlantic provinces, very little reclamation has taken place with the exception of a few isolated mines. Another contributing factor has been the lack of trained manpower and resources to devote to reclamation programs and enforcement. In Prince Edward Island, the major land disturbances are limited to sand and gravel pits. By the mid 1970s demands from the public that something be done about the uncontrolled, haphazard disturbance of the Island's landscape led to the imposition of reclamation regulations in 1976. The province initiated a reclamation program in 1976 whereby the cost of landscaping and aesthetically improving old pit areas was covered by the government. A shared cost program with pit operators and landowners has also received good cooperation in the past five years. Approximately 200 old pit sites have been reclaimed (Murphy, 1981, Pers. Commun.). Adherence to regulations has still not reached one hundred percent.

In Newfoundland with the exception of a few company-initiated projects at metal mines, reclamation activity by the province has not been a priority. Because of the isolation of most mine sites and the dependence on the mines for jobs, they have not aroused significant public demand for reclamation. However, changes in legislation introduced recently may result in increased involvement.

In Nova Scotia there has been very limited activity in land reclamation. Even ministerial provisions under the Environment and Mineral Resources Acts have had little effect. Generally, the principle of non-interference in resource development has been maintained. To date, research activities in the land reclamation field by government agencies have been limited. With the exception of coal mines, most efforts are concentrated on air and water pollution control problems (usually related to health hazards or damage to fish resources). The province has been involved in cooperative programs with the Cape Breton Development Corporation (DEVCO), a federal crown corporation. A program was started in 1977 to cleanup four abandoned underground mine sites at New Waterford and strip mining operations at Alder Point and Point Aconi. The program has been a cooperative one involving three provincial departments, Transport, Agriculture and Environment with the DEVCO environmental staff. The program has not been extended to other types of mine operations. A major objective of the Department of Environment has been to provide active demonstration sites to show that it was feasible to reclaim the abandoned coal mine wastes.

New Brunswick has had a longer history of involvement in land reclamation activities, particularly in controlling the effects of coal strip-mining. The province responded to the adverse publicity levelled at coal strip-mining in the 1960s, by introducing a program of reclamation at the large Minto mine site in 1967. Initiated by the Forest Service, 1,800 hectares of mining wastes were reforested between 1967 and 1974. Today, efforts are concentrated on progressive reclamation at the new Salmon Arm strip-mine.

The effects of base metal mine wastes on fishing in northeastern New Brunswick stimulated efforts to reclaim sulphide ore wastes and prevent water pollution. Initiated by the federal Environmental Protection Service, and coordinated with the province, contract research was undertaken by private consulting firms, university and government agencies to control the effects of heavy metals, sedimentation, toxic compounds and mine wastes on salmon spawning rivers and some reclamation measures were introduced. A synopsis report of the research findings attempted to solve the problem of who was to bear the cost of rehabilitation by recommending that the developer be responsible for internalizing the costs as an integral part of production. It further recommended that:

> ***"The developer outline proposed rehabilitation measures as an integral part of the application or a permit and that he be required to deposit a bond to cover the estimated costs of rehabilitation." (Environment Canada, 1973).***

This approach to determining who would pay the costs of rehabilitation, merely followed the existing trend of legislation in Ontario, Alberta, British Columbia and the United States.

The future growth of reclamation activities in the Atlantic provinces will depend largely on recent and proposed changes in legislation outlined in the previous chapter. A major problem has been the lack of manpower and resources available for reclamation and inspection. Of the 19 projects identified in the Atlantic provinces, eight were initiated by the provinces, two were jointly funded with the federal government, and the remainder funded federally.

QUEBEC

Boivin (1981, 1982) in recent studies has indicated that in southern Quebec 91 percent of the 317 mine sites identified were abandoned without any kind of aesthetic or environmental improvements. Only a few had been abandoned long enough for natural regeneration to ameliorate the site.

Reclamation in Quebec has been in response to health hazards created by dust emissions from tailings and waste dumps or pollution of waterways by mine seepage or industrial effluents. There is no provincial reclamation program either research or operational at this time. Only Noranda Mines Ltd. and a few smaller operating companies that have contracted assistance have active reclamation programs, primarily in northwestern Quebec. To date, only one abandoned mine site has been reclaimed by the province. The abandoned St. Lawrence Columbran mine near Oka was cleaned up (1979-80) due to public concern over reported radioactive waste problems.

Amendments under the Environment Quality Act will result in some changes in the future. Already, the Department of Energy and National Resources, Mining Environment Service has been closing dangerous mine shafts by infilling and grading. But, the program does not include open-pit mines, quarries or sand pits.

However, there has not been any provincial research program or suggestion of one to date.

ONTARIO

Active attempts by companies to reclaim mining wastes have been in progress for more than 40 years in Ontario. Early efforts were directed towards controlling dust from mine tailings and waste rock at Timmins and Sudbury. Ontario has the longest active history of mine reclamation. However, provincial government involvement did not really start until the late 1930s with the formation of the Ontario Water Resources Commission. The Commission's prime task was to ameliorate waste discharge problems from active mining operations. It took almost a decade to develop and introduce air and water pollution control technology and guidelines. It was not until the late 1960s that attention was focused on reclamation as a means of reducing air and water pollution. The formation of the Ministry of Environment in the early 1970s led to more provincial involvement in reclamation at mine sites. Today, two departments, Environment and Natural Resources, are the most active in reclamation programs. Environment has concentrated on metallic mines and Natural Resources on pits and quarries, although there is some overlap. During the past decade one-third of the projects identified were funded or undertaken by provincial agencies, while half were funded by the federal government. The Ontario Ministry of the Environment is concentrating its research on the effects of acid mine drainage, revegetation techniques, species selection and the use of sewage sludges on mine wastes through in-house projects and contracts to the Universities of Guelph and Laurentian.

In the past decade the Ministry of Natural Resources has concentrated its efforts on the problems associated with the Pits and Quarries Control Act of 1971 (outlined earlier in Chapter 2). However, only those aspects directly related to the reclamation of pits and quarries is being considered at this time. The Ontario Mineral Aggregate Working Party Report (Ontario, Government of, 1977) recommended increased involvement by the Mines Branch in providing background information on methods and techniques of reclaiming pit and quarries, as well as preplanning processes which could provide post-extraction land uses compatible with municipal needs. In response to this recommendation, the Mines Branch contracted a number of projects out to the Universities of Guelph and Waterloo and private consultants to provide the necessary background information. This resulted in the publication of a number of reports on the rehabilitation of pits and quarries (Lowe, 1979; McLellan *et al.*, 1979; Yundt and Booth, 1978). In addition, the Branch has initiated rehabilitation demonstration projects.

The new provincial rehabilitation fund established with revenues from increased licence fees will be administered by the Mines Branch for the purpose of conducting the necessary planning studies for, and actual reclamation of, abandoned pits and quarries on a priority basis (Yundt and Messerschimdt, 1979). Although the new "Act" has not been passed, the fees have already been instituted under the old Pits and Quarries Control Act. However, it is unlikely that there will ever be sufficient funds collected to cleanup the considerable backlog of abandoned pits and quarries.

The first cooperative effort between the Ministry of Natural Resources, Aggregate Producers and a local municipality (City of Nepean) is taking place in the Regional Municipality of Ottawa-Carleton. The program is attempting to clean up 650 hectares of disturbed land at 21 sites. A consultant has been hired to develop a plan within the framework of the City and Regional land use planning priorities. It is hoped that it will serve as a model for other areas with high concentrations of aggregates.

As a result of the transfer of jurisdiction for the reclamation of mining properties from the Ministry of Natural Resources (Mining Act) to the Waste Management Branch, Ministry of Environment, a more comprehensive program of reclamation for the province was initiated in 1982. The program includes the following:

"(a) All new, active, idle, and abandoned mining operations in the Province of Ontario will report to the Ministry of the Environment within a given period of time concerning their specific abandonment or reclamation programs. These programs should be to the satisfaction of the Ministry of the Environment and should be completed within an agreed to time frame.

(b) In essence, it is expected that property owners will plant and maintain vegetation or otherwise stabilize all despoiled areas on their property including mine tailings areas, waste rock disposal sites, and any sites containing related debris.

(c) A bonding mechanism is proposed to be used when required to ensure that reclamation procedures are carried out as specified." (Duignan and Hawley, 1980).

In 1977, the Waste Management Branch of the Ministry of Environment established an Abandoned Mines Program using funds from "The Provincial" lottery. The aim of the program was to remove the threat of contamination from abandoned mines and restore thousands of hectares of scarred landscape to a natural state. The Ministry was responsible for setting the needs, and areas of interest, and priorities, and with contracting out all project work unless a clearly defined benefit could be demonstrated for in-house work.[11]

The program developed by the Ministry has four discrete stages (Duignan and Hawley, 1980; Hawley, 1982):

> ***"Stage (1) The documentation of all inactive and abandoned mining operations in the Province in terms of location and ownership. Several thousand such properties exist.***
>
> ***Stage (2) The determination, in a preliminary sense, of the environmental impact of specific properties and, in a preliminary sense, the recommendation of remedial measures to be taken at these properties.***
>
> ***Stage (3) The development, as required, of detailed environmental impact assessments for chosen specific properties and the development, as required, of necessary control technologies.***
>
> ***Stage (4) The actual implementation of control measures at chosen specific properties; in other words, the arrangement of Provincial participation in the implementation of remedial measures where the responsible party cannot be identified."***

By the end of 1981, stages one and two were completed, including detailed chemical analysis of abandoned tailings sites (over 4,000 individual analyses, covering 32 different chemical parameters) and vegetation sampling and analysis on 35 abandoned sites to find suitable varieties for revegetation purposes. The priority for the program now is to begin reclaiming those abandoned sites which pose immediate or potential hazards to health and safety (Hawley, 1982).

In 1978, the Regional Municipality of Sudbury established a Vegetational Enhancement Technical Advisory Committee to formulate plans and find support for reclaiming municipal lands degraded over the years from the effects of SO_2 from local mining smelters.[12] The committee obtained funding from the Ontario Ministry of Natural Resources, Employment and Immigration Canada (Young Canada Works Program) and the Region. The objective was to cleanup and reclaim over 1,000 hectares of land by 1983 (Lautenback and Winterhalder, 1980). The program provided the opportunity of giving university students exposure to reclamation practices and provided funding for staff research in soil characterization, test plots, and experimental seed collection.

The Forestry Branch, Ministry of Natural Resources had been attempting to reforest over 2,500 hectares in the region, since 1973, at a cost of approximately $370/hectare for lime, fertilizer and tree stock. Much of the recent success with revegetation in the Sudbury Region is due to the fact that SO_2 fallout has been reduced locally by the construction of the "Superstack". But this has been at the expense of increased soil and water acidity further north and east.

Overall, with the increased direct role of the Ministry of Environment in both the research and inspection of reclamation, the opportunity for increased reclamation activity seems likely. However, the province has emphasized the applied operational use of funds, so there may be limited funds available for research.

MANITOBA/SASKATCHEWAN

The concern with reclamation in Manitoba and Saskatchewan is a direct reflection of both the amount of mining activity in the province and its location. Until recently, neither province has become directly involved in reclamation research associated with metallic mines in the Shield area. In the past, because of the general remoteness of the metallic and uranium mines, efforts have generally been concentrated on air and water pollution control.

The major focus of reclamation activity in Saskatchewan has been directed towards coal and potash mining where it has been present in the middle of the agriculturally dominated ecumene. A cooperative research program on the effects of potash on crops and soils was established at an early stage by the University of Saskatchewan and Saskatchewan Research Council. Part of the program was to determine what remedial measures would be required, if any, to restore soils to their normal productive capacity. Other research was aimed at finding a safe means of returning the salt brines to unused mine workings in order to minimize the land required for surface disposal.

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[11] Estimated cost for reclaiming all abandoned mining lands in the province was in excess of $125 million, Canadian. (Duignan and Hawley, 1980)

[12] The committee consisted of members from the Regional Municipality, INCO, Falconbridge, Laurentian University, Cambrian College, Ministries of Natural Resources and Environment.

The first coal reclamation work at Estevan was begun in 1949 under the Ministry of Natural Resources. Tree planting continued annually through to 1957, then more emphasis was placed on experimental planting of trees from 1957 to 1972. In 1971, Saskatchewan Power Corporation (SPC, a Crown corporation) started its active reclamation program at the 400 hectare stripped site of the Boundary Dam Power Station. The reclamation Division of SPC has had a continuous research and applied field program in operation since 1971.

An outside Technical Advisory Committee has been formed by the SPC with experts from university and government experienced in the field to aid in the development of a reclamation plan. This process will become a regular feature of coal reclamation programs in Saskatchewan.

Both provinces are currently reclaiming sand and gravel pits associated with Ministry of Transport activities. Manitoba, is in the process of completing an inventory of all pits and quarries in southern Manitoba, with a view to setting up a reclamation program.

Saskatchewan is now moving towards a much more active role in the regulation and environmental control of mine sites in the 1980s, with location of a Mines Pollution Control Branch in Prince Albert and a new Mine Waste Research Secretariat in Regina. The province's order of priority for the development of regulations and programs for reclamation is coal, uranium, potash, metallic mines and other non-metallic mines. The Pollution Control Branch administers the program of abandoned mine reclamation.

In 1980, the province introduced a program to cleanup abandoned mine sites that have been covered by underbrush. It is estimated that more than 100 abandoned mine sites exist in northern Saskatchewan, all of which have been ranked for cleanup according to the amount of traffic in the area and their accessibility. The main focus of the program is public safety, so most of the effort has been directed at permanently sealing and closing the mine sites. In 1980, twelve mines were cleaned up in the Uranium City, Creighton and La Ronge areas. There was little point in attempting costly reclamation programs at these isolated sites, since in most cases tailings wastes were not involved. Most sites involved waste rock, most of which was naturally overgrown with vegetation. Reclamation field tests have started by the Gunnar and Larado uranium mines on tailings and it is expected that further research will be co-ordinated through the new Mine Waste Research Secretariat.

Overall, in the past decade less than 4 percent of the projects identified as having provincial involvement occurred in Manitoba and Saskatchewan. All were directly related to mine reclamation.

ALBERTA

Alberta has the most active and comprehensive reclamation program of any province as a result of the Land Surface Conservation and Reclamation Act, instituted in 1973. The Act is designed to provide a framework whereby development proposals can be reviewed in a coordinated manner and the proper site specific development and reclamation standards can be consistently applied to each successive proposal. Between 1973-1976, there was a rapid growth of reclamation activities for all types of land disturbance.

A survey of reclamation activities in the province in 1976 by the Department of Environment's Research Secretariat revealed that some 127 agencies were involved in reclamation activities (government: 36, university: 26, industry: 37, and consulting: 28) (Sims *et al.*, 1977). Because of a lack of reclamation experience and trained personnel when the Act was introduced, companies and government agencies had to turn to private consulting firms and university personnel who had related experience or transferable knowledge.

However, a number of identifiable problems emerged from the survey, almost all of which were applicable to other provinces with reclamation requirements. It stated that:

> ***"At present, reclamation research in Alberta is fragmented and uncoordinated. Several agencies have jurisdiction and responsibility for reclamation and reclamation research but not necessarily the facilities and expertise required for adequate research programs. Without identified needs and priorities, research has taken a "shotgun" approach. As a consequence, there is danger of duplication of research, funding of low priority programs and ineffective distribution of research results. Millions of dollars will be spent on reclamation in the future, and it is essential that research be carefully planned and coordinated in order to***

> ***optimize the application of funds and scientific knowledge." (Sims** et al.**, 1977).***

Comments by other government agencies echoed the findings, in calling for coordination of reclamation activities and funding, less duplication, more long-term research, and implementation of research results (Smart, 1977; Smith, 1977).

In 1977, the Department of Environment published reclamation guidelines prescribing the standards to be used in determining whether a disturbed site had been satisfactorily reclaimed. However, the most important change in the field of reclamation has been the consolidation of all provincial reclamation research planning, funding and coordination under a single coordinating committee. The Reclamation Research Technical Advisory Committee which was formally established in March, 1978, is an advisory body to the Land Surface Conservation and Reclamation Council and as such makes recommendations regarding research and research funding to the Council (Alberta Land Surface Conservation and Reclamation Council, 1978). The final acceptance or rejection of any proposal lies within the Council's jurisdiction.

The committee's specific terms of reference are:

"1. Assess the nature of reclamation research problems presented to it by the Council.

2. Determine whether fundamental knowledge is already available or whether the problem situation is unique requiring further fundamental study for the purpose of resolving problems.

3. Design comprehensive reclamation research projects for the purpose of filling information deficiencies and resolving the identified problems.

4. Present recommendations as to where the reclamation research should be undertaken by which agency, how much funding should be allocated to it for a specified period of time, etc.

5. Review unsolicited reclamation research proposoals and make recommendations to the Council with respect to:

  (a) the need for the proposed reclamation research in light of-
    (i) existing knowledge
    (ii) current problems
    (iii) anticipated problems

  (b) the adequacy of the proposed design in relationship to the technical problems being studied,

  (c) the location of the proposed field work and laboratory work,

  (d) the technical competence and experience of the reclamation research scientist,

  (e) the relationship of the proposed reclamation research to other ongoing reclamation research.

6. Provide general assistance as required by the Council to develop and implement a comprehensive and coordinated reclamation research program for Alberta." (Alberta Land Surface Conservation and Reclamation Council, 1978).

Table 9 identifies research priorities and attendant projects as of April, 1982.

As well, the government has undertaken the responsibility of reclaiming all surface disturbances which occurred prior to the 1973 legislation, except for sites operated by companies in existence after that date. The Reclamation Branch of Alberta Environment is responsible for coordinating the reclamation of all abandoned disturbed lands, a role it had already been handling. A Land Reclamation Program was established late in 1973.

> ***"The primary objective of the program is to fund reclamation projects and restore those lands for which no responsible operator can be ascertained in order that the land can be returned to a biophysically productive state.***
>
> ***Secondary objectives of the program are:***
>
> ***(a) The creation of a progressive land management attitude among industrial land users in particular and Albertans in general which can be passed on to future generations.***
>
> ***(b) The aesthetic improvement of Alberta's landscape.***

TABLE 9. ALBERTA RECLAMATION RESEARCH PRIORITY AREAS

PROGRAM AREA		PRIORITIES		RESEARCH PROJECT
MOUNTAINS & FOOTHILLS COAL MINING	PHYSICAL PROBLEMS	Coal Ash Disposal	• 79-1-MAC+	Revegetation of ash disposal pits. McIntyre Mines, Grande Cache
		Drill Site Reclamation	• 78-1-LAR*	Survey of revegetation success on abandoned oil exploration sites
	BIOLOGICAL PROBLEMS	Ecology	• 78-3-M/P*	Nutrient uptake rates of Native and Agronomic grasses.
			• 79-8-L/R*	Occurrence of nitrogen-fixing root sheaths on grasses growing in disturbed soils.
			• 82-11-Z/T*	Factors Affecting Development of a Stable Nutrient Cycle.
		Native Species	• 79-7-WEI	Development of Native grasses for reclamation.
			• 79-23-WEI	Alpine and Subalpine test plots for native grass lines
			• 79-5-W/P*	Manual of Grasses, Forbs, Trees and Shrubs for Reclamation in Alberta
			• 80-16-KIN*	Seed pretreatments for native shrub propagation
			• 82-12-TOM	Survey of A.F.S. Native Grass Trials
		Soil Reconstruction	• Company Projects Coal Valley	Materials suitability plots (topsoil blend, spoil), soil depth plots (Capping depths of Topsoil/Subsoil from 0-60 cm). Lodgepole pine seedling performance will be monitored on each treatment. Luscar Ltd.
			• Obed-Marsh	Forest soil reconstruction plots. Various sequences for rebuilding forest soil will be monitored in terms of Lodgepole pine, white spruce seedling performance. Union Oil of Canada Ltd.
	CULTURAL PROBLEMS	Planting	• 79-16-MIH	Establishment of tree and shrub seedlings in erosion controlling cover. Coal Valley, Crowsnest.
			• 79-18-RUS	Evaluation of Native-Agronomic grass and legume mixes. Cadomin
		Fertilization	• 79-23-WEI	Native and Agronomic species' nutrient requirements
			• 78-4-PAR*	Effects of various types of fertilizer on tree and grass performance
		Mulches	• 79-17-TAK	Use of Mat Mulches on difficult slopes. Cadomin.
			• 78-4-PAR*	Effects of peat amendment on tree and grass performance
			• 80-11-TAK	Methods of establishing native grass on unamended coal spoil. Cadomin.

*Project Completed by 31 March 1982
+Cooperative Project with McIntyre Mines Ltd

(c) The employment of Albertans.

...The criteria which had to be met in order to enter into a contract were:

1. ***Funds were to be used in reclaiming public lands (crown, municipal, or tax recovery land owned by the Department of Municipal Affairs).***
2. ***Where possible, work was to be done by a local private contractor.***
3. ***A maximum of $35,000 was to be paid to each municipality to ensure that benefits accrued to all parts of the Province.***
4. ***Reclamation of private lands would require a transfer of ownership to the crown or municipality.***
5. ***The priorities for funding were sites which would demonstrate before and after effects of man's activities and would be in the public interest and useful for education purposes." (Kryviak, 1982).***

The program has reclaimed more than 1,200 individual sites ranging from one-fifth of a hectare to 160 hectares in size. Total investment to date in both the operational reclamation and reclamation research components of the program is in excess of $14 million (Kryviak, 1980). Expenditures on reclamation research have accounted

TABLE 9. ALBERTA RECLAMATION RESEARCH PRIORITY AREAS

PROGRAM AREA		PRIORITIES		RESEARCH PROJECT
PLAINS AGRICULTURAL LANDS	PHYSICAL PROBLEMS	Hydrogeology	• 79-2-MOR	Plains Hydrology and Reclamation Study
			• 79-22-HOD*	Literature Review Effects on Organic Compounds on Salinization
			• 79-27-HOD*	Biogeochemical Processes in Salinization
		Ash Disposal	• 79-1-MAC	Revegetation of Ash Disposal Sites
			• 78-2-MCC*	Variability of Coal Ash
			• 78-20-MCC*	Greenhouse Study Crop Tolerance to Ash in Three Soil Types
			• 78-5-P/R*	Chemistry and Physical Characteristics of Fly Ash
			• 82-5-LES+	Bottom and Fly Ash as Amendment to Sodic Spoils
			• 80-19-MCC*	Radioactivity in Coal Ash
		Overburden Classification	• 79-2-MOR	Weathering Products of Spoils — Inorganic Chemistry
			• 79-27-HOD*	Weathering Products of Spoils — Organic Chemistry
		Erosion Control	• 82-5-LES+	Stability of Topsoil over Sodic Spoil Slopes
			• 82-9-LLO	Establishment of Plant Cover on Dry Sandy Sites in S.E. Alberta
		Landscape Design	• 80-14-MAR*	Integration of Wildlife and Agricultural Values in the Post-Mining Landscape
			• 79-2-MOR	Landscape Design for Optimal Ground Water Quality and Productivity
		Pipelines	• 81-1-HAS*	Evaluation of Pipeline Reclamation Practices on Agricultural Land
	BIOLOGICAL PROBLEMS	Soil Reconstruction	• 82-5-LES+	Reclamation of Sodic Spoils. Reconstruction of Torlea Solonetzic Soils
			• 79-26-FUJ	Chemical Changes in Stockpiled Topsoil
			• 78-4-PAR*	Biological Activity in Stockpiled Topsoil
	CULTURAL PRACTICES	Cropping Systems	• 82-5-LES+	Effects of Small Grain vs Forage Crops on Reconstructed Soils

*Project Completed by 31 March 1982
+Cooperative project with Alberta Power Manalta Coal and Forestburg Collieries

TABLE 9. ALBERTA RECLAMATION RESEARCH PRIORITY AREAS

PROGRAM AREA		PRIORITIES		RESEARCH PROJECT
OIL SANDS	BIOLOGICAL PROBLEMS	Soil Reconstruction	• 79-24-OSE*	Literature Review Soil properties required to meet Reclamation Objectives
			• 78-4-PAR*	Establishment of Biological Activity in Disturbed Soils
			• 81-2-PAR	Microrhizal Potential in Reconstructed Soils
			• 81-3-PAR*	Reinstatement of Biological Activity in Reconstructed Soils
		Shrubs and Trees Selection Propagation	• 79-13-DUN	Selection of Suitable Native Shrubs for Reclamation
			• 81-5-K/C+	Review of Shrub and tree propagation techniques
			• 81-6-K/K+	Shrub seed collection
		Ecology	• Under Development with OSESG[1]	
		Equipment Development	• Under Development with OSESG	
	CULTURAL PROBLEMS	Shrubs and Trees Establishment and Management	• 81-4-P/F+	Review of establishment and maintenance literature
			• 81-6-T/D+	Development of sampling program for shrub studies

*Project Completed by 31 March 1982
[1] OSESG = Oil Sands Environmental Study Group
+Cooperative Project with OSESG

Source: Ziemkiewicz 1982 Personnel Communication Alberta Reclamation Research Technical Advisory Committee for $3.5 million, rising from $154,000 in 1978-79 to $1.5 million in 1981-82 (Ziemkiewicz, 1982).

It should be pointed out that the operational reclamation program was not restricted to mine disturbances. It included a much larger number of abandoned roads, air strips, oil and gas activities, seepage lagoons, garbage dumps, and other disturbances. The inventory of activities conducted for this study included only those projects conducted at mine sites or those designed to be used for all types of disturbances.

Since 1970, 132 research projects related to mine reclamation were identified as having provincial agency involvement, while a further 43 were initiated by the federal government or universities (Appendix 12). An important factor, is the number involving cooperative research with operating companies.

In 1980, the Reclamation Research and Technical Advisory Committee (RRTAC) commissioned a second survey of reclamation activities in order to provide information for establishing priorities in future reclamation research, prevent duplication of research already in progress and assist in promoting communication among agencies involved in the projects. (Walker and Rothwell, 1981). A summary of the results stated that:

> ***"The number of agencies involved in reclamation activities has fallen during the period 1976 to 1980. The total number of agencies involved in 1976 was 127 whereas the number of agencies in 1980 was only 93. Some of this decrease can be attributed to the centralization of government activity under Alberta Energy and Natural Resources and Alberta Environment who jointly supervise the expenditure of Heritage Savings Trust Fund monies for reclamation of abandoned disturbed lands. The number of government agencies fell from 36 to 18. University involvement, mostly research, also dropped from 26 positive respondents in 1976 to 10 in 1980. The number of consultants working on reclamation projects fell from 28 to 16. The number of industrial agencies remained approximately the same, 37 in 1976 and 41 in 1980." (Walker and Rothwell, 1981).***

It is evident that by 1980 the RRTAC had already had some effect on improving coordination and reducing the overlap in government research. The research projects funded by the province have concentrated on three biophysical regions: The Plains, where most of the province's agricultural land is located, the Mountains and Foothills where recreation, forestry, wildlife and watershed values are predominant, and Northeast Alberta, where wildlife and forestry values exist.

> Coinciding with these regions are three major disturbance types:
>
> 1) Plains: Coal mines operated in conjunction with electrical generating plants,
>
> 2) Mountains and Foothills: Metallurgical coal mines and high quality thermal coal for export, and
>
> 3) Northeast Alberta: Oil sand mining and extraction facilities.

There is no question that Alberta has the most extensively funded and coordinated reclamation program in Canada going into the 1980s, the results of which have been the gradual development of a good mix of expertise in the private (consultants and operating companies), university, and government sectors.

BRITISH COLUMBIA

British Columbia was the first province to introduce reclamation legislation under the Mines and Coal Mines Regulations Acts in the late 1960s. The legislation demanded that, prior to filing a detailed plan for the reclamation of areas affected, mining companies conduct research into the techniques required to return the land and water courses to a useable condition. This requirement forced all of the currently operating mines into the reclamation field, unprepared, and without guidelines.

Unlike developments in Alberta, extensive reclamation research by the government was not actively pursued in the first half of the 1970s. The onus has been on industry to carry out its own research either by contracting it out or developing its own research staffs. The effect was similar to that of Alberta's legislation in that a large number of private research companies and university departments were attracted by the demand for specialists with the range of skills to conduct reclamation research and design field tests. The rapid growth in reclamation was also compounded by the larger, and wider range of mining activities in British Columbia. This fact alone presented the developing reclamationists with a greater range of problems to deal with. However, an early preoccupation with short-term revegetation research trials and lack of preplanning and reclamation knowledge has plagued their early efforts.

TABLE 10. SUMMARY OF RECLAMATION PROJECTS IN CANADA:

University Involvement

PROVINCE	LEVEL OF RESEARCH INVOLVEMENT*				TOTAL NO. PROJECTS
	1	2	3	4	
Atlantic Provinces	–	–	–	–	–
Quebec	1	4	2	–	7
Ontario	9	17	6	2	32
Manitoba/Saskatchewan	2	3	–	–	5
Alberta	–	21	11	–	32
British Columbia	2	13	2	–	17
Yukon/N.W.T.	–	9	10	–	19
CANADA	**14**	**66**	**29**	**2**	**111**

*Level of Research Involvement:

1. Actual Site Reclamation Combined with Research Program.
2. Directly Related Research Designed to Reclaim Mining Disturbances.
3. Indirectly Related Research: Research results that could be applied to reclaim various land disturbances.
4. Site Reclamation Only.

See Appendix 3.4 for further details on subject and period of commencement.

Source: Derived from Inventory of Mining Reclamation Research Projects in Canada. Appendix 12

Operational results were poor, costly and not necessarily permanent. In addition, there was considerable overlapping of research and field studies (Dick and Thirgood, 1975; Thirgood, 1971). The legal requirement that each company develop its own technique and set out its own test trials did not lend itself to cooperation in the reclamation field. Initially, however, it led to rapid involvement and some early success, particularly with the larger companies which developed full-time research staffs (e.g. Kaiser Resources Ltd., now B.C. Coal Ltd.; Fording Coal Ltd, and Cominco Ltd.).

Reclamation in British Columbia is administered by the Ministry of Energy, Mines and Petroleum Resources, Inspection and Engineering Division, Reclamation Section. In order to improve reclamation results through better research and information exchange a Technical and Research Committee on Reclamation was formed in 1976.[13]

"(a) to influence and coordinate mine reclamation research in British Columbia;

(b) to further communication and development of knowledge among those concerned with mine reclamation". (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1980).

All of the provincially supported reclamation research programs identified in the inventory (Appendix 12) were initiated after the formation of the committee. In the five year period, 1976-80, some 14 projects were started. Emphasis was placed on metallic tailings research, revegetation of disturbances in the Northeast coal block and the reclamation of abandoned metal mines. This final objective was a result of the 1968 legislation that made all abandoned mines the responsibility of the government.

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[13] The committee is made up of members from government, industry and universities, and is sponsored by the Ministry and the Mining Association of British Columbia.

In addition the Reclamation Section took steps to improve its capacity for providing information exchange and to improve the quality of reclamation work by introducing a system to evaluate the status of reclaimed areas. The system involves:

> ***"(a) permanent sample plots established over a revegetated area;***
>
> ***(b) recording of site conditions;***
>
> ***(c) recording of each species present including an estimate of cover (per cent), seed heads (per cent), height (centimetres), and vigour;***
>
> ***(d) information is recorded directly on computer coding sheets and a summary output is made for each site." (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1980).***

The permanent plots were established to allow for the re-evaluation of sites, to determine the rate of change in composition and performance of revegetation and ultimately to form the basis for final approval and the release of bonds from the operating company. (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1980). Information exchange has also been facilitated by publishing the proceedings of the Annual British Columbia Mine Reclamation Symposium, held since 1977; the preparation of reclamation guidelines; research and bibliographies of published materials pertinent to British Columbia conditions (e.g. British Columbia Ministry of Mines and Petroleum Resources, 1977*a*, 1977*b*, 1978*a*, 1978*b*, 1979, 1980*a*, 1980*b*, 1981; Errington 1979; Hubbard and Bell, 1977; Lavkulich, *et al.*, 1977).

Funds allocated to the Accelerated Mineral Development Program to reclaim mining areas not covered by the present legislation are declining, as are the funds for research (Errington, 1980, Pers. Commun.). Results of vegetation test plots and reclamation activities at operating mines are being computerized and made available to the industry as a whole. Research and monitoring is continuing at the five abandoned metal mine projects. Currently, the committee's priority is to develop a reclamation technique manual for use in the metal mining industry (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1980).

Despite the early start in the late 1960s, provincial support of reclamation research has not been extensive. However, it has benefited from improved coordination and direction. Emphasis appears to be placed on improving the quality of research within the industry through better exchange of information, more thorough inspection of research, and the contracting out of research projects aimed at specific problems or gaps in knowledge.

UNIVERSITY PROGRAMS

University personnel were involved in 111 of the 352 projects identified in the inventory (Table 10). Of this total, 37 were funded through university budgets, the remainder were funded by federal, and/or provincial agencies. Even this figure was further reduced by the fact that 21 of the projects were jointly supported by the mining industry. Only a few universities maintained an early and continuous involvement in reclamation, namely, British Columbia; Alberta; Guelph; Toronto; Waterloo; and Laurentian. Table 11 indicates the other universities and departments identified in the course of this study as participating in reclamation projects at one time or another. Many of the universities were initially introduced to reclamation or revegetation studies through the federal government's Arctic Land Use Research Program and the CANMET Pit Slope Revegetation Program. Similar research and operational programs in Ontario, British Columbia and Alberta have widened the number and range of university departments involved. The largest and most significant program still operating is that found in Alberta.

One of the advantages of these federal programs and similar ones established by Ontario, Alberta and British Columbia has been the development of a pool of scientists and graduate students who are now more familiar with the wide range of physical, chemical and hydrological problems associated with mine wastes. This has been very important with respect to the needs of both the government and industry since few trained scientists familiar with mine reclamation problems were available in the early 1970s. As expected many of the universities have specialized in reclamation problems asosciated with mining activities in their respective regions.

However, the reduction in the funding of projects at the federal and provincial levels (with the exception of Alberta) has seen a decline in university activity in this area in recent years. Another reason has been the gradual introduction of permanent reclamation staff by the operating companies or the reliance on established consulting companies specializing in reclamation. Many of these consulting companies have been formed

TABLE 11. UNIVERSITIES AND COLLEGES INVOLVED IN RECLAMATION RELATED RESEARCH IN CANADA

UNIVERSITY	DEPARTMENT OR RESEARCH CENTRE
Alberta**	Botany, Boreal Institute, Engineering, Genetics, Geography, Geology, Microbiology, Plant Science, Soil Science.
British Columbia**	Civil Engineering, Mining Engineering, Forestry, Plant Science, Soil Science.
Brock*	Geography.
Calgary**	Biology, Chemical Engineering, Environmental Services.
Carleton*	Biology, Geography
Guelph**	Arboretum, Botany, Crop Science, Horticulture, Land Resource Science, Landscape, Architecture, Soil Science.
Lakehead*	Biology.
Laurentian**	Biology, Chemistry.
Laval*	Centre de Recherches sur l'eau.
Lethbridge*	
Manitoba*	Landscape Architecture.
McGill-McDonald College**	Agriculture Engineering, Biology, Geography, Renewable Resources.
McMaster*	Geography, Geology.
Montreal*	Landscape Architecture.
New Brunswick*	Biology, Chemical Engineering, Muskeg Research Institute Forestry.
Ottawa*	Biology, Engineering, Geography.
Queens**	Centre for Resource Studies, Geography, Mining Engineering, Biology, Chemistry.
Regina*	Canada Plains Research Centre, Biology.
Saskatchewan**	Geography, Plant Science, Soils, Science, Crop Science, Agricultural Engineering, Chemical Engineering.
Sherbrooke*	Centre de technologie de l'environment.
Simon Fraser	Geography.
Toronto**	Botany, Chemical Engineering, Civil Engineering, Forestry, Institute of Environmental Studies.
Victoria*	Biology, Resource Energy.
Waterloo**	Biology, Geography, Environmental Design, Engineering.
York*	Geography.

* Minor involvement.
** Significant involvement.

by former university staff members, thus adding to the reduction of university involvement.

Table 10 indicates the distribution of university projects by province and level of involvement. As expected, Alberta and Ontario have the largest amount of university involvement, each accounting for 29 percent. University research on metallic mine tailings accounted for 31 percent of the projects, more than half in Ontario. The remainder were split almost equally between British Columbia, the Yukon and Northwest Territories. The next largest area of interest (71 percent) was revegetation studies to develop suitable grass, shrub and tree species for a wider range of disturbances, (e.g. exploration). The other two leading areas of research interest were the reclamation of coal disturbance (17 percent) and aggregate pits and quarries (10 percent).

CANADIAN RECLAMATION EXPERIENCE

INTRODUCTION

As stated in Chapter One, this study is restricted in scope to a general qualitative overview of the numerous industry, university and government reclamation projects. Due to the very large number of projects identified and their varying degrees of success only a few of the most recent or significant trends in reclamation experience will be reviewed. To facilitate this review, research projects are discussed according to various sectors of the mining industry including coal, oil sands, uranium, asbestos, potash, aggregates and those located north of 60°.

Publication of research information has improved considerably in the past decade with the increase in conference and workshop proceedings, specialized government reports and guidelines, journal articles, bibliographies, and the formation of reclamation associations. But, it is unlikely that any single source will ever cover the full range of conditions that could be expected on mining disturbances across Canada. For those, however, who are or are about to become involved in reclamation programs the following reference materials will provide access to most of the reclamation experience in Canada during the past two decades.

They include:

1. The Ecology and Reclamation of Land Disturbed by Mining: A Selected Bibliography of Canadian References (Marshall, 1980). This publication covers all types of mining disturbances and is available from the Lands Directorate, Environment Canada, 351 St. Joseph Blvd., Hull, Quebec, K1A 0E7

2. Revegetation Information Applicable to Mining Sites in Northern Canada: Annotated Bibliography (Peterson and Peterson, 1977). This is the single most comprehensive source of information applicable to reclamation in the Yukon and Northwest Territories. Available from Environmental Protection Branch, Northern Environment Program, Department of Indian and Northern Affairs, Ottawa, Ontario, K1A 0H4.

3. Pit Slope Manual, Chapter 10 – Environmental Planning (Whitby-Costeau, Shillabeer and Coates, 1977) and Supplement 10-1, Reclamation by Revegetation, Vol. 1 – Mine Waste Description and Case Histories (Murray, 1977) published by the Canada Centre for Mineral and Energy Technology (CANMET). These reports are available from the Publications Distribution Office, CANMET, Energy, Mines and Resources Canada, 555 Booth Street, Ottawa, Ontario, K1A 0G1. The material in these reports pertains to all open-pit mines, with the exception of sand and gravel, and quarries operations.

4. A number of reports have been published by the British Columbia Ministry of Mines and Petroleum Resources concerning the reclamation of mining disturbances in the British Columbia environment. They include:

   - Reclamation of Lands Disturbed by Mining in Mountainous and Northern Areas: A Selected Bibliography and Review Relevant to British Columbia and Adjacent Areas (Hubbard and Bell, 1977).

   - Revegetation Studies in the Peace River Coal Block, 1978 (Errington, 1979).

   - Tailings Research: Selected Mines in British Columbia, 1976-77 (Lavkulich *et al.*, 1977).

   All of the above reports are available from the Inspection and Engineering Division, Mineral Resources Branch, Ministry of Energy, Mines and Petroleum Resources, Parliament Buildings, Victoria, British Columbia, V8V 1X4.

5. In Alberta, the Land Conservation and Reclamation Council is responsible for overseeing programs for reclamation of abandoned distur-

Fording Coal Ltd.'s lathouse for hardening-off and overwintering of seedlings for revegetation programs, Elkford, British Columbia
I. B. Marshall

bances and reclamation research. Through the Reclamation Research Technical Advisory Committee (RRTAC) it has published a number of research reports pertaining to the reclamation of disturbances in Alberta, including:

- Manual of Species Suitability for Reclamation in Alberta (Watson ***et al.***, 1980).
- Proceedings: Workshop on Native Shrubs in Reclamation (Ziemkiewicz ***et al.***, 1979).
- Proceedings: Workshop on Coal Ash and Reclamation (Ziemkiewicz ***et al.***, 1981).
- Land Surface Reclamation: An International Bibliography (Sims and Powter, 1982). This is the most comprehensive working bibliography available.

These reports are available from Publications Services, Queen's Printer, 11510 Kingsway Avenue, Edmonton, Alberta, T5G 0X5. Further information on Alberta's research program and additional published research reports are available from the Chairman, Reclamation Research Technical Advisory Committee, Alberta Energy and Natural Resources, 9915-108th Street, Edmonton, Alberta, T5K 2C9.

6. A Review of Present Research Needs and Research Capabilities Related to the Uranium Mining and Milling Industry in Saskatchewan (Woods, 1981) available from Mines Pollution Control Branch, Saskatchewan Environment, 800 Central Ave., P.O. Box 3003, Prince Alberta, Saskatchewan, S6V 4C1.

7. Report of the National Technical Planning Group on Uranium Tailings Research (Department of Energy, Mines and Resources, 1981) available from Publications Distribution Office, CANMET, Energy, Mines and Resources Canada, 555 Booth Street, Ottawa, K1A 0G1.

8. Specialized Reclamation Equipment (Techman Ltd., 1979) is the only report dealing exclusively with equipment currently available and in use in Canadian reclamation operations. Although prepared for the Canada Centre for Mineral and Energy Technology, it has not been published. Mimeo copies have been made available from Techman Engineering Ltd., 926 - 5th Avenue S.W., Calgary, Alberta, P.O. Box 2840, T2P 2M7. Reproduction costs are charged.

9. Oil Sand Reclamation: A Study Integrating Mining, Tailings Disposal and Reclamation (Techman Ltd. and Rheinbraun Consulting Gmbh, 1979) was prepared for the Alberta Department of Environment, Edmonton. This document will have to be obtained through a library loan or special arrangements.

10. The Ontario Ministry of Natural Resources has published a number of reports specifically aimed at reclaiming pits and quarries.

    - A Guide to Site Development and Rehabilitation of Pits and Quarries (Bauer, 1970).
    - Bibliography: Rehabilitation of Pits, Quarries and other Surface Mined Lands (Yundt and Booth, 1978).
    - Trees and Shrubs for the Improvement and Rehabilitation of Pits and Quarries (Lowe, 1979)
    - Vegetation for the Rehabilitation of Pits and Quarries (Ministry of Natural Resources, 1975)
    - Agriculture and the Aggregate Industry (MacIntosh and Mozuraitis, 1982).

    All of the above are available from the Publications Services Section, Ministry of Government Services, 880 Bay Street, Toronto, Ontario, M7A 1N8.

11. Proceedings of the Annual Meetings of the Canadian Land Reclamation Association (Canadian Land Reclamation Association, 1976, 1977, 1978, 1979, 1980, 1981 and 1982) available from the Canadian Land Reclamation Association, Box 682, Guelph, Ontario, N1H 6L3. The Association also publishes a Reclamation Newsletter available from the same address.

12. Proceedings of the Annual British Columbia Mine Reclamation Symposiums (British Columbia Ministry of Mines and the Mining Association of British Columbia, 1977, 1978, 1979, 1980, 1981, 1982) available from the Inspection and Engineering Division, Mineral Resources Branch, Ministry of Energy, Mines and Resources, Parliament Buildings, Victoria, British Columbia, V8V 1X4.

13. A Manual of Reclamation Practice (Michaud, 1981) available from International Academic Services Ltd. P.O. Box 2, Kingston, Ontario, K7L 4V6.

RECLAMATION PROGRESS

Reclamation at mining sites in Canada has been recorded as far back as 1917, when INCO's newly formed Agriculture Department began reclaiming an old roast bed by covering it with topsoil (Winterhalder, 1978). Only a few mining companies have actually initiated reclamation prior to 1970. In fact recorded literature indicates that only a few mines, namely INCO, in Sudbury; Cominco Ltd. at Trail, British Columbia; McIntyre Mines Ltd.; and Hollinger Consolidated Gold Mines Ltd. at Timmins reclaimed mine wastes prior to World War II (Western, 1973; Winterhalder, 1978; Young, 1969). By the end of the 1960s approximately two dozen companies had begun some form of reclamation activity at approximately 30 separate mine sites (excluding construction aggregate sites). However, much of the attention was focused on the use of revegetation techniques borrowed from agriculture and forest sciences. The main objectives were to reduce wind and water erosion, to control contaminated surface runoff, to reduce slope failures, and to improve the general aesthetics and redevelopment of the immediate mine area.

An indication of the growth and current direction of reclamation activities in mining has been obtained from data in Appendix 16, "Inventory of Reclamation Activities at Canadian Mine Sites". Due to the vast number of mineral aggregate extraction operations (in the thousands) it was not possible to include them in this inventory. Table 12 summarizes data from the inventory according to period of commencement and type of mine and Table 13 indicates the type of reclamation activity conducted at the mine sites, by province and territory. Before 1970, only 30 mine sites exhibited some form of reclamation activity.

In the period between 1970 and 1974, an additional 75 mine sites initiated reclamation programs. A further 32 started programs in the period after 1975. Of the 157 sites identified, almost 33 percent were coal mines, and 57 percent were metal mines. The figures indicate a considerable increase in reclamation activity at mine sites across Canada, but they do not tell the true story, in terms of actual progress. Reclamation of an area in excess of 2 hectares was achieved at only 62 percent of these sites. The remainder have not gone beyond conducting environmental impact studies, laboratory analysis, identifying growth limiting factors, and/or establishing field trials. Two federal government programs – CANMET Pit Slope Revegetation Program and Arctic Land Use Research – accounted for this work being conducted at about 16 mine sites. No more than 45-50 companies were identified as having established reclamation programs either with their own environmental staff or with contracted assistance from private con-

TABLE 12. **SUMMARY OF RECLAMATION ACTIVITIES BY MINING COMPANIES: According to Subject and Period of Commencement**

	PERIOD OF COMMENCEMENT			
SUBJECT	**BEFORE 1970**	**1970-74**	**1975-80**	**TOTAL**
Coal	5	22	23	**50**
Metals	25	43	20	**88**
Non-Metallic	–	2	1	**3**
Uranium	–	3	5	**8**
Oil Sands: Heavy Oil	–	1	3	**4**
Asbestos	–	4	–	**4**
TOTAL	**30**	**75**	**52**	**157**

***Does not include construction aggregate sites.**

Source: Derived from the Inventory of Reclamation Activities by Currently Operating Mining Companies in Canada, Appendix 16.

TABLE 13. SUMMARY OF RECLAMATION ACTIVITIES BY MINING COMPANIES: Type of Activity Undertaken

PROVINCE	TYPE OF ACTIVITY* EIA	FLD	RCL	TOTAL NO. OF MINE SITES INVOLVED
Newfoundland/Labrador	4	4	3	4
Nova Scotia	8	4	4	8
New Brunswick	4	1	3	4
Quebec	22	14	9	22
Ontario	34	26	31	35
Manitoba	3	3	1	3
Saskatchewan	7	6	4	7
Alberta	22	27	19	29
British Columbia	34	31	24	34
Yukon/N.W.T.	10	8	–	10
CANADA	**148**	**124**	**98**	**157**

* Type of Activity: more than one type of research activity may be involved at a single mine site.

EIA: Environmental Impact Assessment. Indicates that biophysical inventories of the mine site were conducted. Included the analysis of physical, chemical and biological conditions, and the identification of limiting factors to reclamation.

FLD: Indicates reclamation and field trials.

RCL: Indicates successfully reclaimed disturbances. (>2 ha)

Source: Derived from the Inventory of Reclamation Activities by Currently Operating Mining Companies in Canada, Appendix 16

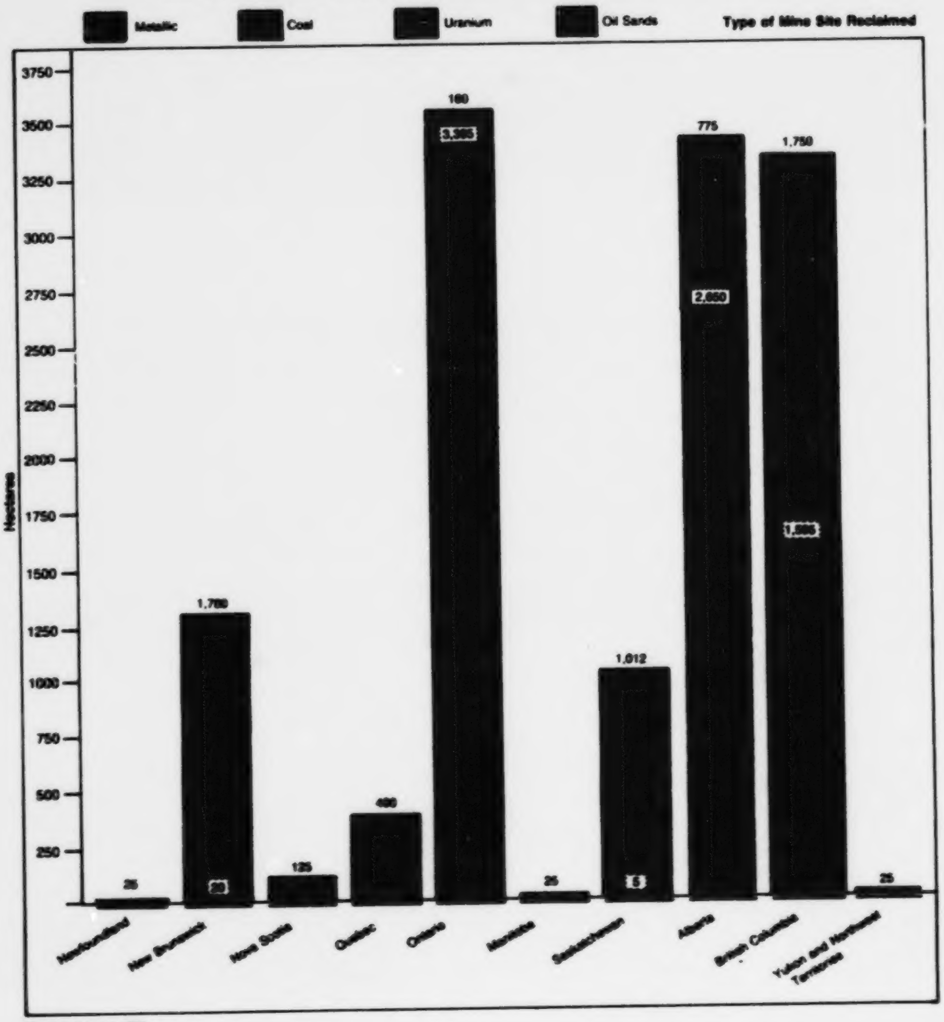
sultants or university scientists. A study conducted for CANMET as part of the Pit Slope Revegetation Program indicated that many Canadian mines lack any active revegetation programs, and only 47 companies indicated they had undertaken reclamation work (Techman Ltd., 1979). However, it should be pointed out that many companies have several mine sites, and research, centred at one or two sites, is designed to apply eventually to other sites as well. In fact, eight of these mining companies have accounted for reclamation at over 50 mine sites under their jurisdiction. In addition, some large companies with their own environmental and reclamation research staffs are now conducting (or advising) reclamation work for other smaller, less experienced operators on a contract basis. In many cases, mining companies have been involved in co-operative research with government agencies or universities at one time or another, or have provided access to, and assistance with, field trials on their mining properties. More and more mining companies are obtaining the services of specialized environmental and engineering consulting companies to design and implement reclamation and long-term land use planning programs. Where information was available, over 40 percent of the mine sites identified in the inventory used private consultants. The heaviest concentration was found in Alberta.

Although there has been a great deal of activity by the increased number of operating companies involved in reclamation, actual progress in terms of reclaimed mine wastes or disturbed sites has been limited. Much of the active operational reclamation at mine sites has been limited to those areas with few growth inhibiting factors: exploration roads; adits; berms; dykes; channel ways; waste rock and overburden dumps; and small scale field tests. The exceptions are several coal strip-mines and a small number of metallic mine waste dumps and tailings ponds.

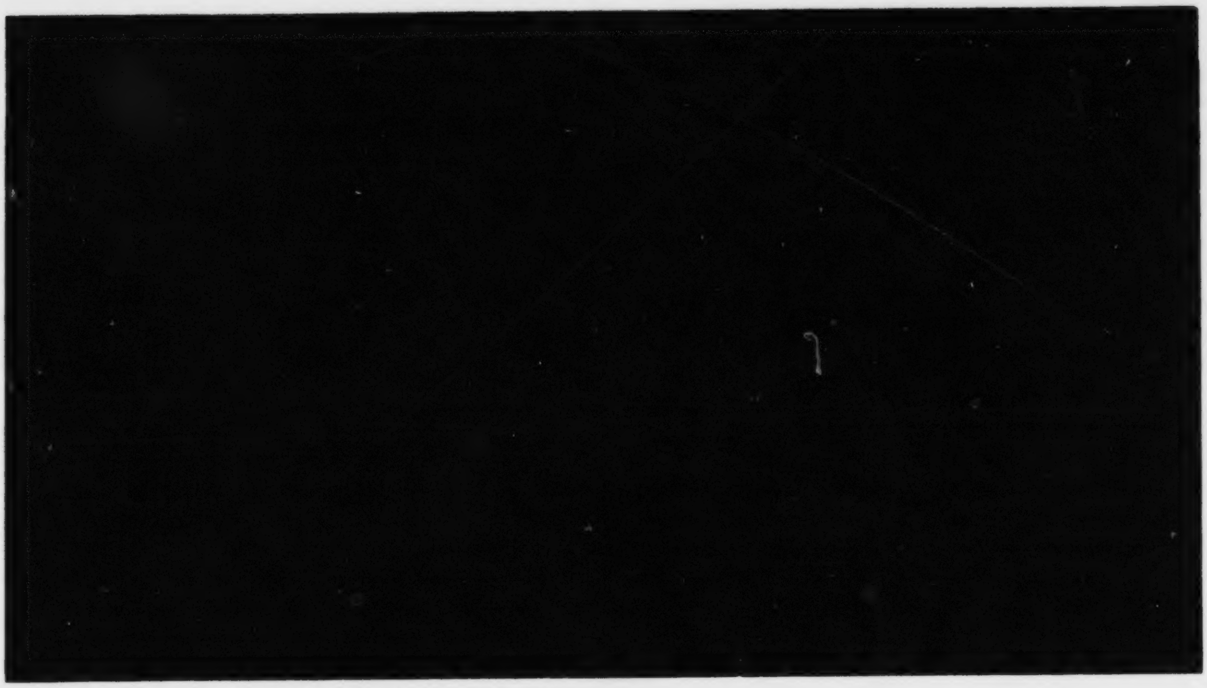
An estimated 13,733 hectares of 133,968 hectares of land disturbed by mine wastes have been reclaimed at mine sites across Canada (Figure 14). These figures do not include sand and gravel, or rock quarries. There is insufficient data available to provide an estimate of the amount of reclamation at pits and quarries across Canada. There is some indication that progress in reclaiming abandoned pits and quarries is being made. The main incentive has been legislation, potential profit from the resale of improved land, and public pressure from the local municipalities. Most of the progress is being made by the large, currently operating companies (Coates and Scott, 1979, Yundt, 1977). In some provinces, (Alberta, Saskatchewan, Manitoba and Ontario) programs have been initiated to cleanup the backlog of disturbed sites, with public funds. In most cases the reclaimed sites have been located within the boundaries of expanded urban centres, and usually

FIGURE 14. ESTIMATED AREA OF LAND DISTURBANCES RECLAIMED: 1980*

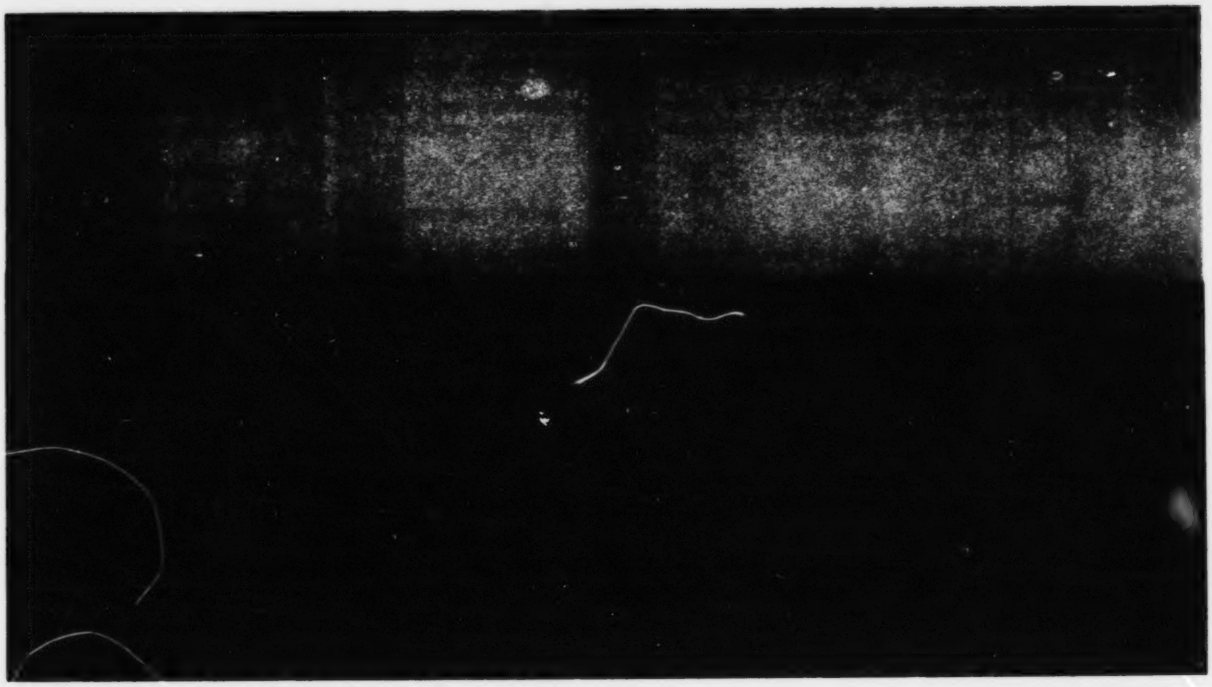
*Does not include sand and gravel pits, rock quarries or exploration disturbances



Source: Marshall 1982



Ridge and furrow pattern of coal strip mining in southern Alberta
I.B. Marshall, Environment Canada



Crop production on reclaimed coal strip mine in southern Alberta
I.B. Marshall, Environment Canada

the prospect of a significant profit to be gained from improved land values has been a prime motivator. Most sites have been successfully reclaimed and developed into landfill sites, playgrounds, parks, golf courses, campgrounds, gardens, as well as industrial and residential sites.

A recent study identified 82 pits and quarries within the Metropolitan Toronto Region (Yundt and Augaitis, 1979), 67 of which had been rehabilitated. Of those rehabilitated, 34 percent are now used for recreational, 27 percent for residential, and 13 percent for educational purposes. Two of the sites were incorporated in the Metropolitan Zoo. Actual cases of reclaiming lands to a condition capable of supporting agricultural production have been less frequent.

Positive benefits have been gained by many municipalities in that the isolated pockets of abandoned undeveloped extraction sites have provided opportunities to develop areas much needed for public use which were neglected in the initial thrust of urban development. Even so, it is unlikely that the huge backlog of abandoned sites (especially small roadside pits) in Ontario and Quebec will ever be entirely reclaimed. In the future, the potential profit motive and/or municipal (township or county) planning requirements coupled with enforced legislation requiring reclamation to a designated land use capability will be the major catalyst in reducing the cumulative total of lands affected by pit and quarry aggregate operations.

RECLAMATION COSTS

Cost data for reclamation at Canadian mines is almost as sparse as it was a decade ago. Comments like "too little data kept by companies to produce a meaningful economic model" (Jewitt, 1972), and "consideration of the economics of reclamation measures has received little attention in reclamation literature" (Berdusco, 1974) are still a relatively accurate assessment of today's conditions.

As recently as 1976 a Federal Government study on Minerals and the Environment revealed that:

> ***"To date, no comprehensive estimate has been made of the full range of public costs associated with environmental protection measures in Canada. Nor has any full assessment been made of the costs to the mineral industry, although partial analysis of the costs of specific regulatory proposals has been undertaken. In the absence of reliable data policy makers seem to have resorted to a number of generalized assumptions about the 'reasonableness' of these costs that, in the case of the mineral industry, understate their importance." (Department of Energy, Mines and Resources, 1976).***

Although referring primarily to the very costly expenditures on air and water pollution control equipment and operating expenses, the same basic problem of "lack of data" is true for activities related to the land reclamation sphere of environmental protection.

The difficulties expressed by mining companies in attempting to keep a separate record of costs attributable to reclamation are generally valid, with respect to the wide range of variables involved. Often, the process of identifying and separating the individual variables in terms of capital equipment, depreciation costs, interest, fuel, labour and maintenance can be a complex task. Some companies still question the relevance of such data, when its usefulness depends so much on how compatible it is to other unique mining situations. Often data summarized in averages or ranges is criticized for being misleading unless the site specific variables are given to place costs in their proper context.

In the past, due to the absence of specific Canadian data on costs, government agencies and companies have referred to the large backlog of American data on reclamation costs for comparisons, particularly with respect to the coal industry. The ecological and climatic differences which reflect the geographic locations in Canada and the United States render most comparisons poor at best. Much of this is due to the existence of United States federal legislation which sets considerably more demanding and inflexible reclamation requirements. Some of the pitfalls of comparing costs between countries, and above all those made between divergent regions within a country are illustrated in a study on coal strip-mine reclamation costs in the United States by W.S. Doyle (1976). It stated that "reclamation conditions, procedures and successes, and hence costs in the eastern United States, particularly in Appalachia have no bearing on conditions to be expected in the western United States". Of equal importance, it revealed that available data for active operating mines is sketchy and probably not very accurate. In most cases detailed costs on the exact type and/or degree of reclamation were unavailable. These findings generally apply to the situation in Canada today.

It is often contended that reclamation requirements add directly to the mining cost, and indirectly affect productivity. If this is the case, and mining companies treat reclamation costs as a definite factor in the cost of production, tied to environmental protection regulations, then a better understanding of the role that reclamation costs play in the total mining operation is important to future mine development. Reclamation requirements are no longer confined to a post-mining operation, they are an integral element of all stages of mining today. Regulations and reclamation standards apply to the exploration, as well as to the development and post-mining cleanup stages of a mine's existence. Therefore more accurate records on the various cost items will provide an effective method of comparing the reclamation techniques between different operators and provide overall cost indicators to regulating agencies. Reliable information that describes project actions and related costs is needed to permit regulating agencies to assess the impact of regulatory requirements.

The review of regulations and policies (Chapter 2) dealing with mining and land resource utilization identified two basic concepts which have gradually taken root. The first is the general acceptance of the concept that while mining is a necessary interim land use lasting anywhere from 5-50 years (usually 10-20 years), the lands involved should be reclaimed if possible. The second is the acceptance of the concept that preplanned, concurrent reclamation is workable, but is dependent upon the location and type of mine. By applying these concepts, the planning and implementation of reclamation activities begins at a much earlier stage. The costs will be enlarged as a result of increased regulatory requirements. A considerable proportion of the costs presently incurred by reclamation activities can be attributed to the above mentioned concepts. In the past, the tendency was to record or extrapolate the cost of direct operational aspects of reclamation (material movement, ground preparation, revegetation, etc.). New mine developments are now faced with considerable data collection in the Environmental Impact Assessment process, directly related to the final designation of a post-mining land use. In addition, considerable research and field testing may be required prior to mining, to prove or disprove the feasibility of using certain reclamation techniques required under the conditions of licence approval. Research and development costs may, in fact, account for up to half of the total reclamation bill. In some cases, solutions may take several years to find after the actual closing of a mine. Alternately, they may delay the opening of a new mining operation for a considerable period of time, until a viable solution is found.

The increased requirements for reclamation coupled with the rising influence of resource management policies has also led to a dramatic increase in the involvement of various government agencies. These demands have added a new dimension to the overall public cost.[14] Often these increased back-up services are not immediately reflected in the overall cost of reclamation requirements since the focus of attention has traditionally been on the activities of the individual mining company. If the regulatory requirements for reclamation are to be met, then there must be a better understanding of the entire range of variables which now contribute to the cost of reclamation.

Better records are needed to understand the impact of regulations on overall costs of operating a mine. It is important to determine what resources are required to meet various reclamation objectives and policies. Accurate cost information is needed to differentiate between which methods are technically and economically feasible now or in the near future. Absence of such information will make it difficult for both the private and public sectors to designate adequate resources to long range problems associated with reclamation.

APPROACH AND DEGREE OF RECLAMATION ADOPTED

To simplify the cost factors involved and degree of reclamation undertaken, two categories of reclamation have been identified: basic and full reclamation or rehabilitation.

(i) ***Basic Reclamation*** is aimed at eliminating at the earliest practical date all undesirable on-site and off-site conditions caused by mining. Usually it includes stabilizing of slopes, controlling adverse chemical or acid discharges, and improving aesthetics. Normally, revegetation is the most physically and aesthetically effective method of stabilizing and rehabilitating mine wastes and disturbed lands.

(ii) ***Full Reclamation or Rehabilitation*** includes the basic reclamation requirements described above, but these will be more specialized to provide for ground preparation (backfilling, topsoil replacement or selective overburden handling) to preselected topographic conditions, and specialized surface treatments and revegetation techniques for the intended use. Normally, this requires the creation of a soil condition capable of supporting plant life equal to that of the regional landscape and provision for use at some economic value. The determination of the post-mining land uses will vary according to government requirements and with incentives in each province or territory. It is obvious there will be considerable latitude in the degree and cost of reclamation in this category.

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[14] Increased government support in the form of research funds, subsidies, specialized advice, inspection, in addition to the more specific information and data collection by traditional government service agencies (geological, soil, hydrological and forest inventories).

There are five broad levels of involvement to which land could be committed in the future. They are in ascending order of involvement (Riddle and Saperstein, 1978):

(i) Wilderness or unimproved use;

(ii) Forestry, limited agriculture, or outdoor recreation (e.g. grazing, hunting, fishing, logging);

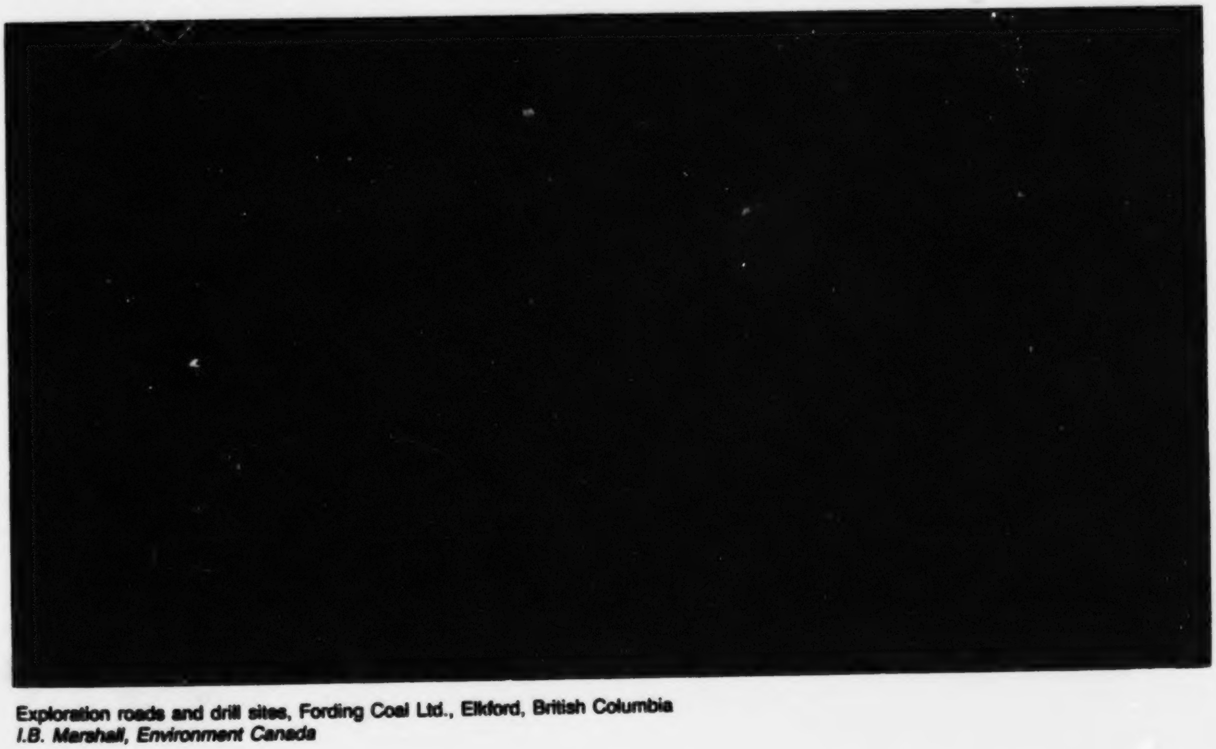
(iii) Agricultural and high-intensity recreation;

(iv) Suburban dwelling or light commercial; and

(v) High-density urban dwelling.

Most of the added costs and efforts are associated with the preparation of the land for new uses. Often new high-intensity uses ensure that a mining company's long-term responsibility is limited or completely terminated. From a practical viewpoint, however, the actual conceptual, spatial, and time aspects of the planning process defy definition because the long-term land use may ultimately develop in response to constantly changing conditions.

The final reclamation plan chosen will be the result of weighing the constraints and finding an optimum balance between them. Usually this will require some form of compromise as no two sites are the same and technical limitations may be present which limit desired objectives. The functional requirements of a chosen land use will be a major factor in determining the design of the post-mining reclamation plan. For example, a coal mine located in the heart of the agriculturally dominated prairies would be required to return the land to some beneficial use based on economic returns, preferably agriculture. Under the circumstances, socio-economic attitudes, aesthetics and regulations demand that the functional aspect becomes very important. In remote areas, on the other hand, the emphasis



Exploration roads and drill sites, Fording Coal Ltd., Elkford, British Columbia
I.B. Marshall, Environment Canada

is less on putting land to some practical use than on ensuring that land is not left in such a condition as to cause any danger to, or degradation of, adjoining areas or to public health.

Therefore, economics, location, aesthetics, and land use play very important roles in determining the alternate function of an abandoned site, and the cost of potential conversion. More technical constraints on the ability to carry out reclamation include limitations imposed by materials found at the site, operational capabilities of machinery and equipment, and known reclamation techniques.

FACTORS INVOLVED IN ESTIMATING RECLAMATION COSTS

There is no generally accepted list of reclamation costs or natural grouping of costs applicable to all mining conditions. The range of factors involved in determining the reclamation costs of a given project will vary considerably according to the degree of reclamation required, size, type and location of mine activities. For the purposes of illustrating the wide range of factors influencing reclamation costs, fifteen cost centres have been identified (Table 14). They represent five broad categories of costs: 1) planning and design; 2) bonds

TABLE 14. **FACTORS INVOLVED IN ESTIMATING RECLAMATION COSTS**

The range of factors involved in determining the reclamation costs of a given project will vary considerably according to the degree of reclamation required, size, type and location of mine activities.

1. **Data Collection:** Baseline inventories for impact analysis and planning. Include field surveys, drilling, sampling, testing, mapping and monitoring.
    - Topography
    - Soil and Surficial Deposits
    - Geology
    - Hydrology
    - Biological: vegetation, wildlife, aquatic and animals
    - Climatic
    - Socio-economic
    - Historic sites
    - Land Use
2. **Environmental and Socio-Economic Impact Assessments**
   Growth limiting factors to reclamation.
   Mitigating measures required.
3. **Planning:** Integration of:
    - Mine layout and engineering
    - Reclamation
    - Water and air quality protection procedures.
4. **Approval Process**
    - Administrative overhead
    - Reclamation plan approval
    - Designated land use approval
    - Annual reports to regulating agencies.
5. **Licence, Permit, Fees, Security Deposits or Bonds**
6. **Research and Field Testing**
7. **Selective Materials Handling:** Includes loading, hauling, placement.
    - Removal of vegetation cover
    - Removal of stockpile of topsoil and overburden. Rehandling overburden and topsoil (concurrent or post mining).
8. **Material Capping**
    - Crushed stone, sand and gravel
    - Overburden, Topsoil
    - Organic material.
9. **Ground Preparation**
    - Backfilling
    - Shaping and contouring
    - Ripping and grading
10. **Surface Treatment:** physical, chemical stabilizers
    - Mulches
    - Sealants
    - Matting/blankets
11. **Amendments**
    - Lime
    - Fertilizer
12. **Revegetation**
    - Seedbed preparation
    - Seed and/or trees, shrubs
    - Grass and legume seeding
    - Tree and shrub planting
    - Hydro seeding
    - Hand seeding
    - Specialized requirement for designated land uses
13. **Drainage and Sediment Control**
    - Slope stabilization
    - Grading and ditching
    - Dewatering
14. **Irrigation**
15. **Maintenance and Monitoring Programs**
    - Vegetation
    - Erosion
    - Drainage

and security deposits; 3) materials handling and ground preparation; 4) revegetation; and 5) maintenance.

In calculating operational costs of reclamation, normally the following items are included: capital equipment costs and depreciation; interest; fuel; power; maintenance; and labour. However, they are not always easy to separate from the regular mining operation, particularly when the same equipment and men are used interchangeably.

Planning and Design

In the pre-production stage the early emphasis is on baseline data collection for analysis and subsequent development of mine production, reclamation, land use, and monitoring plans for the project. The early planning allows for the practical storage of topsoil (overburden) and careful placement of wastes, to complement the final post-mining reclamation plan. At the same time, planning provides for the setting-up of adequate testing programs (revegetation, drainage, slope stability, materials) to meet specific land use objectives (when required).

The additional data requirements for the environmental assessment, reclamation, and land use planning generally require consideration of the following: topography, soils and surficial deposits, geology, hydrology, biology, climate, socio-economic and historical aspects, land use, regulations and zoning, and permit approval processes.

In the case of open-pit or strip-mining, the most expensive steps in the reclamation process are placing waste overburden at desirable slopes, backfilling the high walls, contouring, terracing, selective placing of overburden, and maintaining proper drainage patterns (Peterson and Etter, 1970). Therefore when these processes can be incorporated into the mining operation, considerable economic savings are possible in the post-extraction reclamation phase.

In a study of United States coal strip-mines, it was estimated from actual cost figures that:

> ***"costs could probably be reduced by at least ½ if reclamation had been conducted along with the mining"***
>
> ***"...the expense of clearing and grubbing of volunteer vegetation, disposal of burned trees and brush, loosing of compacted spoil and re-establishing access to areas could be saved"***
>
> ***"...the cost of contouring could be reduced by ⅔ if done immediately following mining" (Doyle, 1976).***

Under the circumstances it is not surprising that many of these activities can be directly related to the costs of reclamation, including the administrative overhead associated with the reclamation plan approval process, annual reports and bonds or security deposits posted. However, not all of the cost factors associated with the planning and design category will apply to mines in

TABLE 15. **BIO-PHYSICAL SURVEY COSTS NORTHEAST COAL BLOCK BRITISH COLUMBIA**

	$ / SQ. MI.	**$ / KM²**
Surface geology	8	3.10
Vegetation	45	17.40
Soils	23	8.90
Hydrology	28	10.80
Wildlife	44	17.00
Climate	36	13.90
Recreation	6	2.30
Visual	9	3.50
Cultural, historical	12	4.60
Administration	33	12.70
Data Handling: publication	29	11.20
TOTAL	**$273**	**$105.40**

Source: Sneddon. Pers. Commun. 1980

TABLE 16. ESTIMATED COSTS FOR ECOLOGICAL LAND SURVEYS

(i) Costs of Representative Large Area Surveys

TITLE DATE	COMMENTS	AREA km^2/year	PRINCIPAL SCALE	UNIT COST[4] \$Can/km^2
Mackenzie Valley 1971-1974	Boreal, several settlements with easy access[1]	77,500	1:125,000	2.33
Melville Island 1975	Arctic tundra, one village inaccessible[2]	15,500	1:125,000	8.90
Boothia Peninsula 1974	Arctic tundra, two villages moderate access[3]	64,400	1:125,000	3.10
James Bay 1973-75	Mainly boreal, several towns and hydro developments	117,000	1:125,000	7.74
Northern Development 1975-76	Boreal. Several towns and villages, moderate access	62,640	1:125,000	3.48
Yukon Territory 1975	Mountainous, boreal to tundra, moderate access	536,327	1:1,000,000	0.18
Northern Yukon 1977	Alpine and arctic tundra Two DEW stations	35,000	1:500,000	1.43

[1] Easy access means daily scheduled flights to main communities.
[2] Inaccessible means no scheduled flights to the area.
[3] Moderate access means weekly scheduled flights to at least one community.
[4] Unadjusted for inflation — see date.

(ii) Estimated Costs of Small Area Surveys

TITLE	TYPICAL APPLICATIONS	SCALE	EXPECTED COST \$ Can/km^2
Semi-detailed regional planning	Location and design of development projects; type and intensity of land use	1:50,000	54
Detailed regional planning	New town location, impact assessments	1:25,000	247
Very detailed project and management	Subdivision site location, site management	1:10,000	927

Source: Welch *et al.*, 1981.

operation prior to the establishment of reclamation requirements. Normally, these mines are faced with an after-the-fact situation, as most provinces are with previously abandoned mine sites that have reverted to their jurisdiction. Usually this results in increased costs and fewer reclamation options.

The recent Northeast Coal Block background study provides an example of the basic data collection costs that can be incurred in the Environmental Impact Assessment and preplanning phase of a new mining region. The baseline inventories for impact analysis and planning including field surveys, sampling, testing and mapping covered a total area of approximately 14,400 square miles (37,000 square kilometres) at a scale of 1:50,000, and took 3 years to prepare. (Sneddon, 1980, Pers. Commun.). The cost came to \$283/square mile. Administration and data handling accounted for 22 percent of the total costs. The cost of the various components is shown in Table 15.

Welch ***et al.*** (1981) have prepared estimated costs for large and small area ecological land surveys, which incorporate surface materials, geology, soils, vegetation, hydrology, and wildlife. The scales in Table 16 reflect cost ranges as one goes from broad regional to site specific needs. However, it should be noted that the field surveys and sampling are less extensive than those conducted in the Northeast Coal Block study, hence the lower costs.

Operational reclamation costs at Cominco Ltd's Bluebell (lead-zinc) and Pinchi Lake (mercury) operations in British Columbia illustrate research and administrative costs on metallic mine wastes and tailings. At the Pinchi Lake mine site, between 1970 and 1978, 64 percent of a total $108,000 was spent on research and administration: (Stathers and Gardiner, 1979). Most of this was spent on research to find an acceptable method of revegetating the tailings and waste rock areas. The objective was primarily basic reclamation to improve plant growth conditions, and encourage self-sustaining native plant communities. On a single year operational basis, administrative and travel costs were 28 and 9 percent respectively of the total cost in 1978. This involved the basic reclamation of 10.5 hectares (26 acres) of a tailings disposal area and waste dumps.

In contrast, to reclaim a smaller 5.3 hectare (13 acre) site at the Bluebell mine (4.5 hectares (11 acres) of industrial site, 0.8 hectares (2 acres) of waste rock and tailings) research and administration costs accounted for 23 percent of the $35,000 spent since 1972. Several factors account for this difference. First, the site was considerably smaller, and only 0.8 hectares (2 acres) were actually mine wastes. Second, the goal was full reclamation or rehabilitation to a forest-wildlife-outdoor recreational use, which required the added cost of applying 43 centimetres of overburden and special grading in places. Finally, there were few growth inhibiting problems, and the research costs can be reduced when a single company has its own reclamation research staff, attempting to find solutions for more than one mine site. In 1978, the actual administrative costs to reclaim the 5.3 hectare (13 acre) site came to only 11 percent of the total.

For many mining companies, a considerable portion of the final reclamation cost per hectare will reflect early research costs or field tests. This situation may decline in the next decade as the result of a wider base of research in the industry as whole, and as the body of data from successfully reclaimed sites becomes available. Much of the reclamation work in the 1970s reflects the earlier research and field testing period.

Bonds, Permit Fees and Security Deposits

Bonds, permit fees or security deposits have become another element of reclamation costs. Most provinces levy reclamation bonds or security deposits for reclamation on the basis of a set dollar/hectare rate, (see Table 1, Chapter 2). The exceptions are Ontario for aggregate operations and Alberta for coal operations, both of which charge on a per tonne of product basis. The per hectare charge ranges from $1,235 to $5,000. In Alberta large coal mines must pay an initial security deposit of $25,000, and pay an additional 25 – $2.00 per tonne of coal produced depending on circumstances (Harrington, 1979). An example of recommended security deposits for exploration activities in Alberta is shown in Table 17. The money is held in trust until the successful completion of reclamation. In some cases of progressive reclamation during operations, funds can be released on an annual basis.

TABLE 17. **RECOMMENDED SECURITY DEPOSITS EXPLORATION REVIEW COMMITTEE ALBERTA**

	PLAINS REGION	**FORESTED REGION**	**FOOTHILLS REGION**	**MOUNTAIN REGION**
Drill Hole / Site	$ 50	$ 150	$ 200	$ 300
Adits / Site	$ 1,000	$ 1,500	$ 2,000	$ 2,500
Trenches / 100 feet (backhoe only)	$ 25	$ 50	$ 75	$ 100
Reclaiming New Access / mile	$ 400	$ 800	$ 1,500	$ 2,500
Reclaiming Old Access / mile	$ 200	$ 300	$ 500	$ 1,000

Source: Harrington, 1979.

In most cases, an interest rate is paid on funds held in trust, but there remains a cost associated with the loss of use of the funds. In 1979 the Province of British Columbia held over $4.7 million in security bonds, $3.6 million of which was deposited by 20 producing coal and metal mines or an average deposit of $181,150 (British Columbia Dept. of Energy, Mines, and Petroleum Resources, 1980). Total deposits for all regulated activities in Alberta for the same year came to $3.2 million, while over $550,000 was refunded for successful reclamation at 76 sites (Harrington, 1979). By March 1980, deposits totaled $6.5 million, with refunds of $594,000 for successful reclamation of 65 projects (Alberta Environment, 1980).

Materials Handling, and Ground Preparation

There are four cost centres identified in this category: selective materials handling; material capping; ground preparation; and drainage and sediment control (***see*** Table 14, Nos. 7, 8 and 9). This category is the most costly of all the operational reclamation processes. Selective materials handling is normally associated with coal, and aggregate operations, but it has now become a requirement at most new mine operations. Most new mines require the removal and storage of topsoil and overburden for either concurrent or post-mining reclamation. Material capping is usually associated with metallic mines, where almost any material free of growth inhibiting agents can be used to establish a vegetative cover. Slope stabilization, grading and ditching and dewatering will be necessary in order to improve drainage and sediment cotrol. Finally, some degree of ground preparation is normally required, before any revegetation can take place.

Revegetation

The three cost centres associated with the revegetation category are: additional surface treatments; soil amendments; and the various stages of the actual process of revegetation (***see*** Table 14, Nos. 10, 11 and 12). Surface treatments of mulches (straw, bark, brushwood) and/or adhesive chemical stabilizers (resinous adhesives, bitumin, polymers) are used as a means of preventing erosion and aiding the establishment of a vegetative cover. Treated surfaces are seldom permanent, and costs are high. Used on their own the results are not as aesthetically pleasing as vegetation. Soil amendments to neutralize acidity or make up nutrient deficiencies are usually required in large amounts in the initial years, and can be required on an annual maintenance basis for a longer period.

Principally, revegetation is the process of establishing a vegetative cover on mineral wastes or mined areas so as to:

(i) Stabilize erodible slopes in order to minimize stream pollution;

(ii) Control dust;

(iii) Maximize aesthetic value;

(iv) Maximize evapotranspiration to minimize run off;

(v) Facilitate product land use (e.g. agriculture, forestry); and

(vi) Reduce oxidation – potential acid mine drainage (Williams, 1975).

It is the most physically and aesthetically effective method of stabilizing and rehabilitating mine wastes and disturbed sites. The highest costs will be associated with revegetation programs aimed at developing a productive biological post-mining land use.

There are two basic approaches to revegetation of mine wastes and disturbances (Down and Stocks, 1977). The first, is to accept adverse soil and site conditions as they exist and choose plants which have a tolerance to the main environmental factors inhibiting plant growth (Down and Stocks, 1977; Goodman, 1974; Murray, 1977***b***). This has been referred to as the "ecological" approach, emphasizing "native" or "volunteer" species.

The second approach is to improve the soil and site conditions to make them suitable for the growth of the particular species (often agronomic) required. In the case of the first approach, it must be recognized that there are still some severe conditions under which no species could survive (e.g. severe high sulphide acid tailings). If the second method can be used, more-rapid results as well as a wider choice of after use can be anticipated. In practice, a combination of the above approaches is widely adopted and with varying degrees of success (Hubbard and Bell, 1977; Le Roy and Keller, 1972; Murray 1977***b***).

Where many environmental factors inhibit plant growth at a single site, revegetation becomes a complex task. Under these circumstances research and applied field testing costs will increase significantly.

In other situations, only a single site-specific problem may be the major factor limiting successful revegetation. Much can be done in site preparation through slope and drainage modifications and material capping to reduce costs in the final revegetation process.

Follow-up Maintenance and Monitoring

A management program of monitoring and maintenance is necessary to ensure that the goals of the reclamation or abandonment plan are met. The monitoring period is normally stipulated in regulations, and usually must be carried out over a specified time after final augmented seeding, refertilization, replanting and drainage changes. Some regulations may require that monitoring continue for several years to assess whether or not the operator has fulfilled his obligations to adequately reclaim the site, and in order to release reclamation funds or bonds posted with the government as security.

Monitoring focuses on areas where revegetation has been less successful, where there are signs of erosion, siltation, or slope failures. Most problems are associated with south- and west-facing slopes, old access roads, former equipment or storage sites, high runoff sites, areas high in clay content, salts, heavy metals, or toxic compounds. Retreatment usually consists of chemical, physical, or biological improvements.

Additional applications of fertilizer or lime are the most-common chemical treatments used to assist the establishment of permanent vegetation (hence erosion protection) or to increase the build-up of the organic content of the soils. Physical treatments are normally associated with erosion, or slope failures. Maintenance can involve some earth moving, remulching, netting, fencing, or other stabilizing techniques. Biological changes or improvements include changes in seed mixtures or plant species, and replanting.

In some cases, irrigation may be desirable or necessary for reclamation in arid areas of the prairies and the interior of British Columbia. However, the high capital and labour costs associated with irrigation methods and availability of water may preclude its use. Irrigation has been used to dispose of available sewage effluent on mine tailings in British Columbia (Lane and McDonald, 1979).

Revegetation test plots on abandoned mine tailings, Hilton Mine, Quebec
W. B. Blakeman, Environment Canada

ASBESTOS

Almost all the reclamation research conducted on serpentine asbestos mine wastes has taken place in the asbestos mining belt of the Eastern Townships of Quebec. The Geography Department, McGill University with financial and logistical support from the Quebec Asbestos Mining Association has been working on the problem of revegetating asbestos tailings since 1971. The area involved is approximately 5.5 square kilometres of conical mounds or flat topped dumps, all with side slopes of 30 to 35 degrees (Moore and Zimmerman, 1979). The main reasons given for attempting to revegetate the tailings are the aesthetics of the area and the fact that revegetation has the potential of reducing health hazards associated with wind and water borne asbestos fibres.

In previous studies, Moore and Zimmerman (1973, 1974, 1975, 1977) identified the major physical and chemical properties inhibiting the establishment of plant growth on the asbestos tailings as:

(i) highly alkaline (pH 9);

(ii) low availability of the major macronutrients nitrogen, potassium, phosphorus and calcium;

(iii) the ability of the tailings to "fix" nutrients, particularly calcium;

(iv) high concentrations of nickel and chromium and their potential availability and toxicity when the pH of tailings is lowered below about 8;

(v) low organic matter content and somewhat low microbiological population;

(vi) low available water capacity, droughtiness;

(vii) poor structure, surficial erosion on steep slopes and the tendency for rainsplash movement of fine particles;

(viii) formation of cemented surface crusts, retarding root development (the crust can develop in the top 20 centimetres several years after dumping);

(ix) possible heat scorching of plants due to low albedo of the tailings.

Field trials conducted since 1973, showed that high rates of fertilizer (N,P,K, and Ca) and organic matter (farmyard manure or sawdust) were necessary to establish a vegetative cover. Increasing the acidity of the tailings did not improve plant response (Moore and Zimmerman, 1977). It was determined that the addition of organic matter was absolutely necessary to ensure good plant growth. However:

> ***"the high pH of the tailings causes the volatilization of ammonia from ammonium fertilizers, also retarding seed germination at high levels of ammonium fertilizer addition, and the tailings are unable to retain nitrate-nitrogen." (Moore and Zimmerman, 1979).***

As an alternative sewage sludge was tested as an organic amendment on flat and sloping (25-30 degrees) plots at different rates with and without N,P,K fertilizers. It proved to be successful in maintaining a greater than 90 percent cover (using commerically available grasses and legumes) with local volunteer species becoming established (Moore and Zimmerman, 1979). In terms of large scale reclamation, the authors pointed out that the high costs of transporting the bulky organic materials from urban sources to the mines inhibited their use. In addition, there are problems in attempting to incorporate the organic wastes, fertilizer and seed on water dumps with some angles up to 35-40 degrees. But, they point out that part of the cost may be absorbed by the producers if they have need for a disposal site.

An alternative approach is being tested on the tailings, using western grass species used to the droughty alkaline conditions of the Canadian prairies. Seeds have been provided by Agriculture Canada, and tested in laboratory trials, with wild rye grass and Russian wild rye grass performing well. Tree seedlings planted on the tailings have done poorly, and only the trembling aspen did reasonably well. This may be due to the droughtiness on the porous tailings, compounded by physiological drought induced by high amounts of fertilizer necessary for plant growth (Moore and Zimmerman, 1979). The authors recommend reclaiming with trees only after a healthy self-sustaining cover of grasses is established. At this time, the above mentioned problems make it difficult to undertake any large-scale reclamation program.

POTASH

There are approximately 3,000 hectares of land affected by potash mines in Saskatchewan. All the potash mines are underground and surface disturbance is actually quite small, with the largest area being affected by salt waste dumps and brine ponds. Nothing can be done to reclaim these dumps while still in operation. Efforts have been directed to mitigating the effects of wind blown KCL dust, which is rarely detected beyond 5 kilometres of the mine site (Sentis, 1974).

The Saskatchewan Institute of Pedology, University of Saskatchewan conducted a series of field tests and growth chamber experiments on the effects of the dust from the mine sites on soils, between 1966-1977. They determined that up to 11.2 tonnes/hectare of KCL could be added to a siltloam or loam soil without any reduction in crop yields occurring (Ballantyne, 1974). It was determined that soils contaminated by the potassium in mine dust can be ameliorated by adding dolomite (up to 22.4 tonnes/hectare), which supplies Ca and Mg for plant growth and improves the physical properties of the soil. In addition the pH of the slightly acidic surface soil was increased. Crop yields were restored to original values provided the KCL did not induce saline conditions.

Rates of 33.6 tonnes/hectare KCL added to a non-saline siltloam soil did not make the surface 45 centimetres of the soil saline, but did cause the lower depths to become saline (Ballantyne, 1978). Further research on reclaiming actual disturbances may be introduced in the near future with the establishment of the Mines Waste Research Secretariat by the Province of Saskatchewan.

AGGREGATES

The technology and planning procedures needed to reclaim or rehabilitate aggregate pits and quarries are already available and proven (Blauch, 1978; Ontario, Government of, 1977). There is a considerable base of literature on the subject published in the United States and the United Kingdom in the 1960s (Johnson, 1966; National Sand and Gravel Association, 1961; Schellie and Bauer, 1968; Schellie and Roger, 1963). In Canada much of the research and operational experience has been developed in Ontario during the 1970s (Aggregate Producers Association of Ontario, 1976; Bauer, 1970; Coates, 1973, 1974; Lowe, 1979; McLellan *et al.*, 1979; Ministry of Natural Resources, 1975). The research approach begun in Alberta in the mid-1970s has been directed towards finding various domestic and native species of grasses, shrubs and trees capable of being used for reclamation on a wide range of disturbances, in different ecological zones (Alberta Agriculture, 1981; Ziemkiewicz *et al.*, 1979). Since the results of the Ontario Mineral Aggregate Working Party Report were published (Government of Ontario, 1977), there has been a considerable increase in the number of companies which have initiated reclamation programs and cooperated with university and government agencies in operational field tests. However, one of the difficulties in assessing progress is that the publication of the results has been very limited.

Successful reclamation to recreation, forestry, natural areas, residential and commercial urban uses are not uncommon and have not faced undue physical and chemical problems (Caston, 1978; Dewitt, 1978; Giergon, 1978; Hewitt and Vos, 1970; Scott and Armstrong, 1978; Yundt and Augaitis, 1979).

Efforts to rehabilitate former pits to agricultural production have been more recent. For example in Ontario a number of companies have been able to establish crop growth, including clover, alfalfa, corn, soybeans, oats, barley, wheat and sour cherry orchards (Sterrett, 1978; Yundt, 1977).

In 1979, a study was conducted by the Ontario Ministry of Natural Resources to assess the extent and success of agricultural rehabilitation in southern Ontario (MacIntosh and Mozuraitis, 1982). Sixty-three sites were found to have a genuine agriculture after use. Most sites were less than 3 hectares in area and only two sites included more than 10 hectares. The study indicated that 60-70 percent of the sites could be considered successful in their rehabilitation programs. The success rate was remarkably high considering the lack of guidelines available to the industry on rehabilitation to agriculture (MacIntosh and Mozuraitis, 1982).

A good indication of the overall "state of reclamation" progress and problems still outstanding is the findings of "A Study on Pit and Quarry Rehabilitation in Southern Ontario" commissioned by the Ontario Ministry of Natural Resources (Coates and Scott, 1979).[15] Some of the more pertinent findings are as follows:

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[15] The study was limited to licenced sites, therefore, the results do not necessarily apply to abandoned pits and quarries, no longer licenced, or to worked out sites which have been rehabilitated and been in after use for some time.

"... A breakdown of site condition classification, within the two general categories of Rehabilitation and No Rehabilitation, showed classification, on an acreage basis, as follows:

REHABILITATION	
Completed Rehabilitation	*2%*
Progressive/Partial Rehabilitation	*31%*
Preliminary Rehabilitation	*11%*
NO REHABILITATION	
Screening Berming	*31%*
Revegetating Naturally	*4%*
No Rehabilitation	*16%*
Reserve	*5%*

... Construction of earth berms and screening along the perimeter of sites was not considered to be rehabilitation work.

... Landform was considered to be the most important general aspect of rehabilitation as it controls the suitability of the site for biologically and economically productive after-use.

... Rehabilitation by filling a pit or quarry back to original surface level was not common.

..."Green" uses were the majority of after-uses reported for rehabilitated areas. Reforestation and conservation represented 36% of reported after-uses and agriculture represented 35% of after uses.

... Producers reported that their major reasons, or motivations for carrying out rehabilitatin were; legislation 35% public image 30% and financial gain 20%.

... Sources of information on rehabilitation utilized by producers were company personnel and other aggregate producers 47%, consultants 43% and Ministry of Natural Resources 10%.

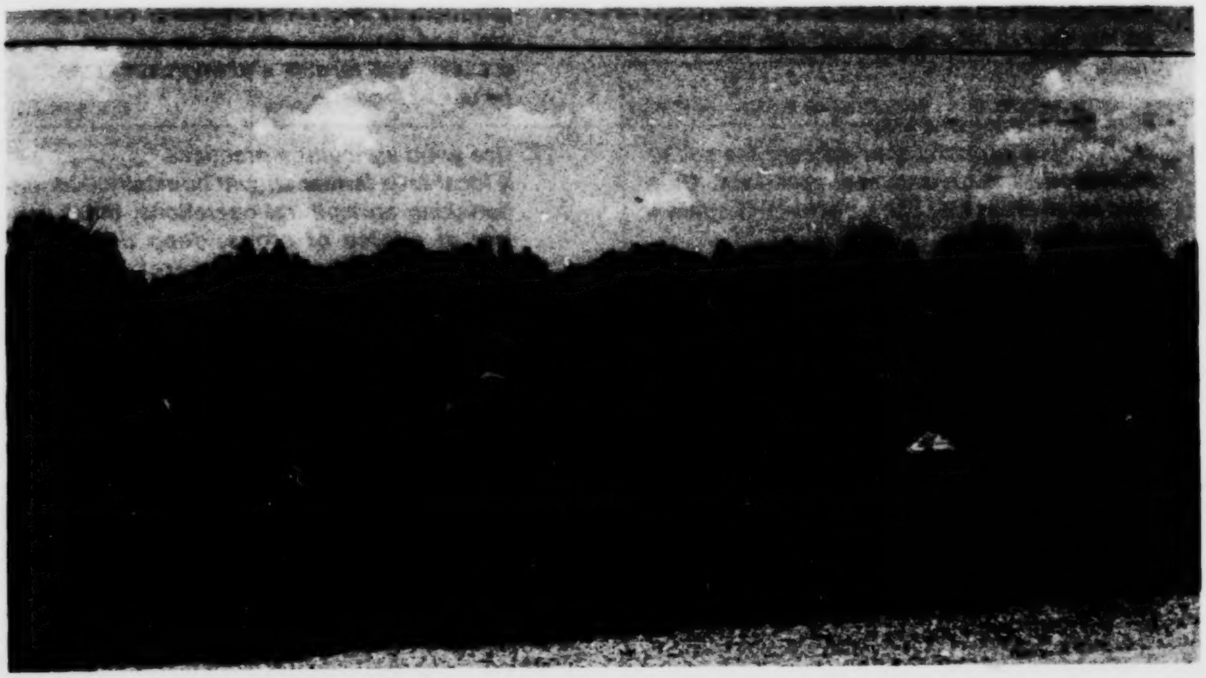
... Progressive rehabilitation, or the simultaneous strip and replace method, was reported to be about half as expensive a method of earthwork as the traditional strip – stockpile and replace-at-the-end method, 59% of producers reported that rehabilitation earthwork was either a routine part of normal operation or that they practiced progressive rehabilitation on a regular basis.

... No new methods or techniques of rehabilitation were discovered. Earth-moving and earth-shaping practices were found to be conventional utilizing normal construction equipment, bulldozers, frontend loaders and dump-trucks. Planting methods for herbaceous ground covers and trees were conventional. High mortality rates and stunted growth are characteristic of many rehabilitation tree plantings. Little attention is given to proper staking or support of trees above seedling size, irrigation after planting, mulching, protection against rodent attack and protection from competition by established meadow vegetation for available water, light and nutrients.

... Planting practices were generally not up to the standards necessary to create satisfactory rehabilitation vegetation cover. Considerable improvement is required in understanding and utilizing proper agricultural, horticultural and forestry practice with respect to soils management, species selection, planting technique, planting layout and maintenance procedures.

... Assessment of the limited number of tree and shrub planting programs shows that little attention has been given to establishing species diversity and to selection of species for particular value as wildlife cover and forage. 67% of the sites assessed for wildlife habitat characteristics were classed as 'simple' or monoculture vegetation communities. Current planting and maintenance practices contribute to this situation through single species plantings and mowing of herbaceous vegetation for neatness. Mowing prevents volunteer invasion by native woody species which would create a more natural species diversity." (Coates and Owen, 1979).

In a separate study of pits and quarries conducted for the same Ontario Ministry of Natural Resources about one-third of the 85 reclamation sites investigated needed additional planting and improved maintenance (Lowe, 1979). Many of the sites could have benefited from a better choice of species and planting arrangements. In many situations better site conditions would have improved site rehabilitation. The study resulted in the publication of a manual on trees and shrubs for use in rehabilitating pits and quarries, and should prove to be of considerable assistance to operators.



Abandoned borrow pit south of Ottawa, Ontario
Robert Audet, Environment Canada

The ability to rehabilitate former extraction sites to agricultural production is dependant upon overcoming a number of specific adverse physical conditions. MacIntosh and Mozuraitis (1982) identified the most pertinent ones found in southern Ontario. However, they generally apply to sand and gravel pits throughout the agricultural areas of southern Canada.

One of the most common reasons for slower progress in this area is that the techniques essential to rehabilitate pits to agricultural uses cannot be used, because topsoil and subsoil had not been carefully removed and stockpiled separately when the extraction first started. Prior to the establishment of reclamation legislation, topsoil and subsoil were often sold for additional revenue. The authors indicated that a minimum of 15 to 20 centimetres of topsoil is required for optimum restoration conditions; thus the cost to purchase this amount and/or subsoil in addition could be prohibitive.

Poor drainage was the second major problem encountered due to: extracting down to or below ground water levels; down to impermeable layers of silt or clay; and/or the failure to design surface water drainage outlets for the site. A minimum of one meter of combined topsoil and subsoil overlying a water saturated soil zone is desirable for adequate agricultural plant growth during the growing season.

The other problems identified were primarily related to operational reclamation procedures and post rehabilitation management which could readily be corrected with access to proper advice or information. They included: "excessive stoniness, subsequent cropping programs, compacted pit floors, and inadequate treatment of applied topsoil and subsoil to ameliorate compaction problems" (MacIntosh and Mozuraitis, 1982).

The most common post management problem identified was the choice of crops. Preferred initial crops are forages which will return organic matter to the soil, build up natural fertility, and improve soil structure. Most operators tended to grow corn or grain crops immediately.

MacIntosh and Mozuraitis (1982) provide an illustrated step-by-step procedure for rehabilitation of old sites back to agricultural production. The authors have identified 12 steps to successful restoration of agricultural lands. They are summarized below:

> ***"1. Pre-planning***
> ***It is vital to know, in advance, what has to be done, but the plan should allow for modifications if these become necessary.***
>
> ***2. Strip the topsoil, subsoil, and overburden separately.***

The materials must be handled and stored separately. Do not intermix topsoil with other soil material.

3. ***Strip small areas at a time.***
   Stripping off ground cover exposes the soil to increased erosion and sediment loss. Only strip small areas that can be extracted within a reasonable time.

4. ***Move soil materials under dry conditions.***
   Soils are more easily damaged when wet and should be moved mainly during the drier months of June through September inclusive.

5. ***Rehabilitate progressively.***
   Topsoil may deteriorate in storage i.e. berms, or may be lost.
   Progressive rehabilitation allows for direct movement of soil and prevents these harmful effects as well as reducing the cost of earth moving.

6. ***Grade and countour the pit floor.***
   There must be an overall plan for draining the land including a drainage outlet for surface water runoff. Slopes between 2 and 5 per cent are desirable for agriculture purposes.

7. ***Replace overburden (if any), subsoil and topsoil in the correct sequence.***
   There should be about one metre of topsoil/subsoil/overburden overlying ground water levels to provide for adequate plant growth.

8. ***Calculate volumes, depth and areas to be covered carefully.***
   A common problem encountered is insufficient soil to finish restoration.

9. ***Eliminate severe soil compaction.***
   Severe soil compaction can be avoided by moving soil materials when dry and by using lighter equipment. Where severe soil compaction has occurred, it may be necessary to undertake deep ripping (subsoiling) in conjunction with the reapplication of topsoil/subsoil/overburden.

10. ***A post rehabilitation management program is critical for success.***
    A period of at least five years is required to restore the soils to their original pre-extracted productivity levels. The choice of crops is crucial and emphasis should be placed on increasing soil fertility and improving structure by use of legumes.

11. ***Use good agriculture practices.***
    A local area farmer should be retained for undertaking agricultural operations. Strict control of choice of crops, deep tillage and fertilization should be exercised by the operator.

12. ***Be patient.***
    Successful restoration is a slow process. Any attempt to shortcut the procedures outlined will only increase the opportunity for failure." (MacIntosh and Mozuraitis, 1982).

On the basis of field evidence, the authors stressed the need for preplanning and in particular the need "to strip and retain all topsoil and subsoil from a site, to pay closer attention to the depth of extraction in relation to water table levels, and the need for developing a well planned, post rehabilitation management program" (MacIntosh and Mozuraitis, 1982).

Outside of Ontario and Alberta there has been very little reclamation research in the aggregate industry. In other provinces and territories, the recent introduction of reclamation requirements for pits and quarries, will probably result in some research being supported by provincial agencies in order to overcome local and regional sites conditions which may have unique problems. As in Alberta and Ontario, regulatory requirements will gradually result in more companies or their contracted consultants (private or university) becoming involved.

In all cases, very little research or operational reclamation has taken place at quarries or clay pits, both of which have serious natural restraints to and options for reclamation. Another area that has lacked attention has been the subsurface movement of water in reclaimed sites and the readjustment of water tables.

Some indication of the cost of rehabilitation to a successful agriculture after-use were obtained from the Ontario Ministry of Natural Resources rehabilitation claims reports for the Cambridge District in southern Ontario. Rehabilitation to agriculture uses ranged from $1,712 to $13,710 per hectare, which included earth moving, trimming, grass seeding and mulching, initial planting of grass and legumes, with chemicals and fertilizers (MacIntosh and Mozuraitis, 1982).

TABLE 18. COMPARISON OF RECLAMATION COSTS FOR PITS AND QUARRIES (SAND, GRAVEL, STONE)*

LOCATION	REFERENCE	MINE TYPE	DATE	COST/ha	COST BREAKDOWN	COMMENTS
Dufferin Aggregates, Milton Quarry, Niagara Escarpment	Dewitt, F. J. 1978	Quarry	1976-78	$14,208	$586 Ripping & Grading; $3,106 Topsoil (15 cm); $2,811 Revegetation (trees, plants, mulch); $1,853 Final Screening; $3,954, Planning and Administration	Relocation of plant, Aesthetic screening. Open space — conservation.
Ontario Aggregates Producers, Glen Major Demonstration Site	Caston, W. 1978	Sand & Gravel	1977	$2,467	$1,800 Ground Preparation $637 Revegetation, including fertilizer	Forest, wildlife conservation area.
Arboretum, University of Guelph, Estimated costs for small (1 ha) pits	McClellan *et al.* 1979	Sand & Gravel	1979	$1,235		Basic reclamation; grading and seeding.
Nelson Crushed Stone, North Burlington, Ontario	Yundt, S.E. 1977	Quarry	1976	$5,000	$36,300/ha to grade, slope, seed and plant shoreline areas only	60 ha shoreline and lake for recreational use (high level).
Nelson Crushed Stone, North Burlington, Ontario	Coates and Scott 1979	Quarry	1976			Points out that the final averages of $5,000/ha reported above (Yundt) will be considerably lower over the total site (220 ha).
TCG Materials, Brantford Ontario	Yundt, S.E. 1977	Sand & Gravel	1976	$4,643	$4,450/ha Ground Preparation and Topsoil. $519 ha Revegetation	Reclaimed to Agricultural Use — Wheat field Approximately 3 ha.
Flintcote Co. of Canada Ltd., Brant Co. Ontario	Coates and Scott 1979 Caston 1979	Sand & Gravel	1977	$7,796	$7,277/ha Ground Preparation $159/ha Revegetation	Basic Reclamation. Aesthetics, conservation, trees and shrubs. 4 ha site.
J.C. Duff Ltd. Limehouse R.M. Halton, Ontario	Coates and Scott 1979 Caston 1979	Sand & Gravel	1976	$16,474	Ground Preparation and Revegetation	Basic Reclamation: Aesthetics, conservation, 3 ha site.

*The cost per hectare show here should be taken only as an indication of the range in overall costs that may be expected than a close guide. The cost will reflect only specific conditions and will vary from site to site due to variation in approach and final objective.

Earlier published figures for reclamation costs in Ontario are illustrated in Table 18, covering a wide range of rehabilitation objectives. Most of the examples given did not have the benefit of preplanning or progressive rehabilitation techniques. Reclamation was conducted a number of years after operations had commenced or after the operations had closed down. Costs ranged between $1,235 and $16,474 per hectare. Preplanning and progressive rehabilitation techniques should bring the upper end of this cost range downward considerably (particularly on new sites).

It should be noted that the cost figures are only an indication of the range in overall costs that may be expected. The cost will reflect only site specific conditions and will vary from site to site according to variation in approach and final objective.

URANIUM MINES

An Overview of Canadian Environmental Research in the Uranium Industry by Schmidt and Moffet (1979) provides the most comprehensive review of reclamation research up to 1979. The recent Report of the National Technical Planning Group on Uranium Tailings Research (Department of Energy, Mines and Resources, 1981) contains an overview of uranium tailings production, physical and chemical properties and pathways by which chemical constituents can reach the environment and man, and current tailings management procedures.[16] In addition, research and development carried out to date on uranium tailings is reviewed. The major portion of the report deals with the modelling, national measurement and disposal alternative programs. Finally, the planning group developed a national research program designed to find solutions for the safe management of wastes after uranium mine and mill operations have shutdown. As indicated earlier in Chapter 3, it was on the basis of this report that the federal government (CANMET) introduced its National Uranium Tailings Program in 1982.

Overall in Canada there are an estimated 1,061 hectares of land affected by uranium mine wastes (Marshall, 1982). This includes twelve inactive and ten active tailings sites, covering a total of 316 and 319 hectares respectively. To date, three of the inactive sites have been revegetated and one partially, revegetated. However, all of them still have acid generating problems (Department of Energy, Mines and Resources, 1981). Two inactive and five active sites are located in Saskatchewan, the remainder are in Ontario.

The major problem is with the tailings. Dusting and erosion can take place when they settle and dry. The sulphide minerals common to the Elliot Lake ores (e.g. pyrite) in the presence of moisture will oxidize to form sulphuric acid, which subsequently leaches heavy metals (copper, lead, zinc, cadmium and radionuclides) resulting in an "acid seepage problem" (Schmidt and Moffett, 1979). The biggest concern is the effect that the low pH, increased heavy metals, and radionuclides will have on water, biota and sediments in the larger drainage basin once operational treatment procedures are terminated on final close-down of the mine.

The basic thrust of present research and development efforts on uranium mine wastes is towards a close-out option that requires no operational controls to be in place and which will not require any human intervention. Five broad close-out options have been identified: surface storage; shallow burial; deep burial; deep lake disposal; and removal of contaminants in the mill process (Department of Energy, Mines and Resources, 1981). The discussion which follows relates primarily to the surface storage and shallow burial options.

Surface storage has been used at all Canadian uranium mills and, whatever the method adopted at new sites, the problem of close-out and reclamation remains at the old sites. Shallow burial involves covering the tailings in natural or man-made depressions or pits with about 3 metres of earthfill to reduce erosion and the release of radon (Department of Energy, Mines and Resources, 1982). Recontouring, landscaping and revegetation would follow. The problem with this method is that very little additional overburden is readily available in the Precambrian Shield in sufficient quantities to bury the tailings. Research on the ramaining three options is aimed at reducing or overcoming the physical and chemical problems associated with tailings disposal (by within mill treatment) or eliminating surface disposal (deep burial or deep lake disposal) and hence the need for specialized surface reclamation procedures.

Current tailings management practices involve:

> ***"– the use of relatively impermeable deposition basins and retaining dams***
> ***– siting of new tailings areas away from any water course, or the diversion of water courses away from tailings areas***
> ***– upon shutdown the removal of precipitate from treatment ponds for disposal elsewhere, and the grading of tailings to preclude the ponding of water***
> ***– vegetation at sufficient density to stabilize the surface, increase evapotranspiration and reduce the amount of oxygen and water reaching the tailings."(Department of Energy, Mines and Resources, 1981).***

The direction of current research work related to surface close-out options requiringreclamation includes:

> ***"– vegetative stabilization to minimize water and wind erosion, reduce penetration of water and oxygen to the tailings to minimize***

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[16] The Group was composed of federal, provincial, industry and university sponsors or performers of research on uranium tailings.

waterborne release of radium, and improve the visual impact of tailings

- ***physical-chemical stabilization to inhibit acidic and radioactive seepages, eliminate wind and water erosion, and isolate the tailings from the environment; methods include chemical fixation, encapsulation by asphalt, concrete, clays, etc., and pelletization using various binders and glazes***
- ***alternative surface placement techniques to maximize the capacity of a tailings management area, minimize the size of retaining dams and optimize the ability to stabilize tailings after shutdown; methods include thickened discharge and coning, stacking and sub-areal discharge***
- ***improved dam design and basin floor amendment to minimize permeability." (Department of Energy, Mines and Resources, 1981).***

Extensive research into reclaiming uranium mine tailings has been attempted for over a decade at a number of mine sites in the Elliot Lake region of Ontario. Research has involved Rio Algom Ltd., Denison Mines Ltd., Canada Centre for Mineral and Energy Technology (CANMET), Environment Canada, University of Guelph and the University of Waterloo.

Rio Algom Ltd. was the first company to initiate research in 1969 and CANMET's Elliot Lake Laboratory began research in 1971 (Murray, 1971). Denison and Rio Algom in cooperation with CANMET have been successful in reclaiming over 160 hectares at mine tailings sites in the Elliot Lake region. However, prior to field scale reclamation trials, the effects of a wide range of variables were studied, including seed blends, mulches, chemical binders, limestone, irrigation, companion crops, organic garbage, sewage sludges and neutralizing agents.

Researchers at the University of Guelph and CANMET Elliot Lake laboratory carrying out laboratory trials showed that composted municipal garbage wastes, sewage sludges, limestone and rock phosphate were all suitable amendments for the acid tailings (Murray, 1971, 1973; Watkins and Winch, 1973). Subsequent field tests at the Nordic site started in 1973 making use of the most efficient and cheapest form of amendments on the highly acid tailings. This was subsequently amended by chemical fertilizers (Moffett ***et al.***, 1977; Murray and Moffett, 1977). It was determined that coarser tailings (75 percent + 300 mesh) required 18 tonnes/hectare of limestone, and finer tailings (96 percent - 300 mesh) required 72 tonnes/hectare. The best mixture of grasses found suitable was Creeping Red Fescue, Red Top or Kentucky Bluegrass.

An alternate approach was carried out at the Williams Lake site in 1976 where 2 hectares of tailings were stabilized using an overburden capping (sand and gravel) and revegetation method. As far back as 1972, 10 tons/acre of limestone was added, then in 1975, 150-300 centimetres of local overburden material was spread before seeding and fertilizing. (Murray and Moffett 1977; Murray ***et al.***, 1977). Although successful, it is expensive ($12,284 per hectare) and involved fertilizer amendments till 1980 and irrigation (at $10,465 per hectare) in order to achieve a self-sustaining vegetative cover.

In 1976 radioisotope uptake in four species of grasses was examined (Moffett and Tellier, 1977). Concentrations of uranium and radium −226 appeared to be too low to indicate any potential hazard. In addition, CANMET studies on the use of coniferous trees for tailings reclamation were initiated in 1974 (Murray, 1978). By 1981, the survival of cedar, pine and spruce was 0, 18 and 28 percent respectively, in previously vegetated sites (Murray and Turcotte, 1982). These investigations attribute the low survival rate to high competition from the established grass cover and disease.

By 1977 Moffett and Tellier (1977) indicated that stabilization of uranium tailings by revegetation (grasses and legumes) was possible, although whether or not on a self-sustaining basis was still to be determined. But the main limitation was the pervading problem of the quality of seepage and runoff from tailings. Early concern about this led to studies on the impact of vegetation on quality of runoff and seepage, which was begun in 1974 by Environmental Protection Service, Waste Water Technology Service. Bryant ***et al.*** (1979) indicated that the recommended rates of lime applied had no effect on the leaching rate of various radionuclides. In 1975, Rio Algom Ltd. in cooperation with CANMET started a five-year experiment to determine the effect of vegetative surface treatment of tailings areas on effluent quantity and quality of seepage at Quirke Lake. This and other projects related to the seepage problem have been covered by Okuhara (1978), Moffett and Tellier (1978), and de Korompay (1979).

More significant are the recent results of research conducted by members of the University of Waterloo, Earth Sciences Department, on hydrological and geochemical conditions of inactive tailings in the Elliot Lake region between 1979-1981 (Blair, 1981; Blair ***et al.***, 1980; Cherry ***et al.***, 1980; Feenstra ***et al.***, 1981; Shepard and Cherry, 1980). Inactive uranium tailings in the Elliot Lake region originally deposited with effluent had a pH range of 8 to 10, but pyrite oxidation has caused the pH of pore water to decline to the 1-3 range (Cherry ***et al.***, 1980; Feenstra ***et al.***, 1981). It is most active in the upper most metre and the concentrations of radionuclides in the acidic pore water are above the standards for drinking water. At the same time heavy metal and iron concentrations are high enough to degrade the quality of surface water receiving the acidic seepage. The acidification has continued to occur in areas where the tailings have been revegetated.[17]

The authors point out that it appears that the method of reclaiming the uranium tailings using limestone, grass cover and refertilization is an ineffective means of preventing tailings acidification and infiltration. As such, the long-term potential hazard to the environment continues, since the amount of tailings acidified increases each year, thus increasing the amount of acidic seepage containing radionuclides and heavy metals.

However, if reclamation techniques are to continue to be used, some method of reducing subsurface pyrite oxidation will have to be found. The objective of establishing a vegetative surface cover is to reduce the rate of pyrite oxidation below the cover to a level that causes the acidic pore water to be gradually replaced by a neutral pH water with low concentrations of heavy metals and radionuclides. This has not worked, although it has reduced erosion and physically stabilized the tailings in the short run. It is for this reason that future research must concentrate on controlling the hydrological conditions in the tailings. This area of research will undoubtedly be supported, since it is also the key to long-term reclamation of other sulphide ore tailings. The alternative is to find a within-mill treatment.

Wood (1981), in a review of research needs in Saskatchewan, points out that results from Elliot Lake may not necessarily be tranferable to Saskatchewan conditions. He suggests that plant species native to northern Saskatchewan and wet areas in site-specific field trials be attempted. He recommends that the type of research conducted by Cherry, (1980), Blair (1980, 1981), Shepard (1980) at Elliot Lake be instituted at Saskatchewan sites.

The report of the National Technical Planning Group on Uranium Tailings Research concluded that:

"1. There is a need to coordinate and synthesize the results of measurements already made on Canadian tailings.

2. There is inadequate understanding of the physical, chemical and biological processes that take place in the tailings and in the pathways from the tailings to the biosphere.

3. There is insufficient evidence so far, based on measurements alone, as to the extent of the long-term problem in the close-out of a uranium tailings basin.

4. There is a need to establish standardized measurement methodologies to improve the uniformity and quality of data taken at different sites across Canada.

5. Generic research and development on tailings disposal technology that applies to more than one site should be within the scope of a national program, whereas site-specific work is the purview of the mines and regulatory agencies.

6. The uranium producer's contribution to the national tailings program should be their R & D work on site-specific disposal alternatives." (Dept. of Energy, Mines and Resources, 1981).

METALLIC MINES

Prior to the introduction of reclamation requirements in legislation of the early 1970s, the report of the National Advisory Committee on Mining and Metallurgical Research (Rabbitts ***et al.***, 1971) indicated that only 637 hectares of mine tailings and waste dumps had been reclaimed at metallic mines. They estimated that this figure would increase to 2,246 hectares by 1975 under the impetus of new legislation and research activities. By 1980, the amount of reclaimed mining wastes in the metallic sector of the industry had increased to approximately 5,480 hectares, or less than 10 percent of total waste disturbances (Marshall, 1982).

There are many reasons for the relatively slow progress to date, some of which are listed below:[18]

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[17] There may be a different advance rate for the "acidifying front" in each vegetated and non-vegetated tailings site.

Abandoned uranium tailings at Bicroft mine, Bancroft, Ontario
W.B. Blakeman, Environment Canada

(i) Actively enforced legislation has only been a product of the 1970s, and it has had only varying degrees of success in the different provinces. A large amount of the land was disturbed long before environmental concerns or legislation were ever considered.

(ii) Responsibility for the reclamation of abandoned mine sites is still a difficult legal problem in some provinces and indeed, in many cases, will ultimately depend on the commitment of a province to do so and on the degree of importance attached to the need for cleanup of individual sites by the respective provinces. Many abandoned sites are now quite remote with little or no access and accordingly would have a low priority for reclamation.

(iii) Metallic mines operate for extended periods of time (usually between 15 to 20 years) before closing down. Uncertainties during the initial stages and unexpected changes in ore grade or market conditions often make reclamation planning impossible on active pits, waste dumps or tailings areas. Commonly pits and waste dumps have to be extended due to increased amounts of waste (lower grade ores) or unexpected new ore reserves. In many cases the cleanup and reclamation of land must wait until a waste rock dump or tailings pond is no longer operational, or until the mine finally closes down due to depletion of reserves. Adverse market conditions may further delay clean-up through a series of temporary closures or cessation of operations. As long as mine tailings, waste dumps and extraction sites are still operational, very little actual progress is feasible beyond the research area test plot scale. Another problem with reclaiming by revegetation in Canada is the climate, which often limits operations to a few weeks in the spring and a few in the fall of each year.

(iv) The very high percentage of metallic sulphide ore mines has tended to significantly reduce the potential amount of disturbed land that can be successfully reclaimed at this time. Although there have been isolated examples of successful reclamation, the low pH's and toxic heavy metal con-

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[18] Many of the reasons given here apply to other types of mines as well.

tent of pyritic and pyrrhotitic sulphide ores have prevented long-term solutions even with massive annual doses of lime or limestone. Revegetated sites continue to require high fertilizer and soil amendments, and few can be left untended for any length of time. In many cases, it will take well over five years to establish a successful self-sustaining vegetative cover.

(v) Contributing to this lower success rate was the speed with which other mining companies adopted successful methods and materials developed by the International Nickel Company of Canada in Sudbury, and generally with poor results (Watkin and Watkin, 1982). This is particularly true of sulphide ore tailings which have such a wide variation in physical and chemical conditions, that each site requires its own methods and materials.

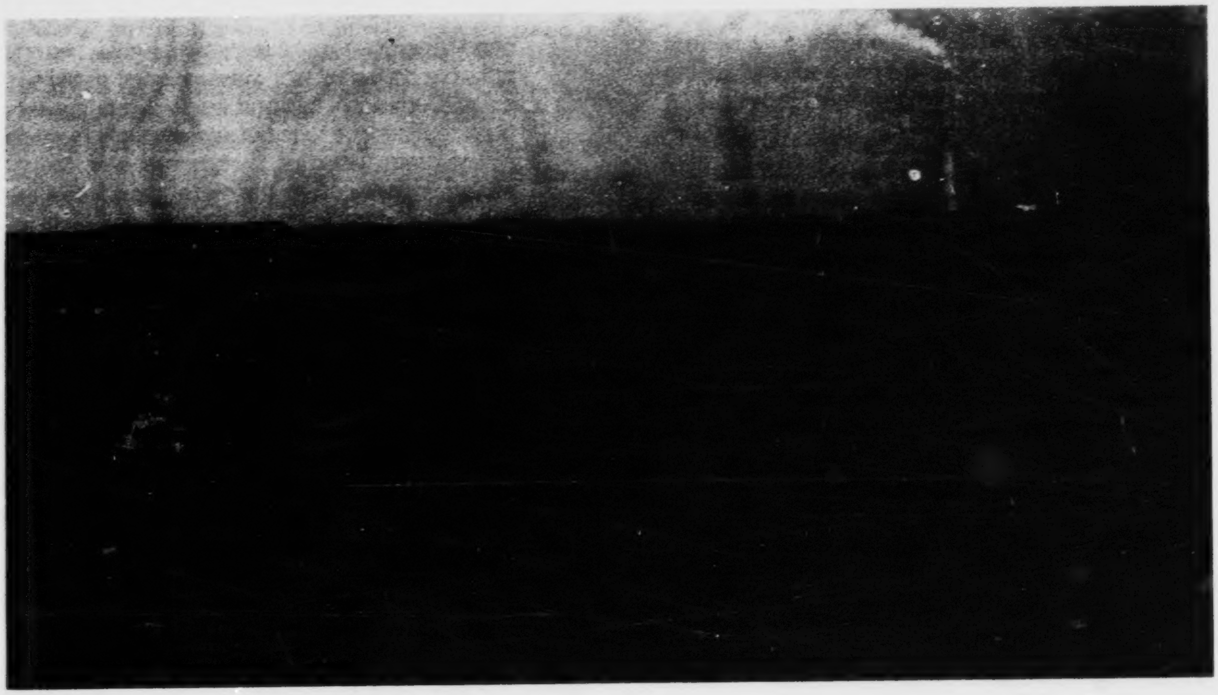
(vi) Overall reclamation of disturbed mine sites is still a relatively recent experience, and significant gaps still exist in the technology.

In recognition of the vast backlog of unreclaimed sites and particularly in view of current economic circumstances, it is unlikely that the backlog of land disturbed by metallic and non-metallic mines (excluding construction materials) will be reduced at any significantly increased pace in the near future.

Most of the companies involved in reclamation are attempting to reclaim their mine wastes in order to achieve one or more of the following ends:

> **"– *Fugitive dust control***
> **– *Erosion control to prevent dam wall rupture***
> **– *Erosion control to prevent run-off of surface particles and subsequent sediment disposition in water courses***
> **– *A reduction in water volume seeping through acid and heavy metal contaminated wastes***
> **– *Aesthetic improvement of waste areas***
> **– *Acceleration of natural succession on waste areas." (Watkin and Watkin, 1982).***

Physical, chemical and environmental characteristics of metallic mine wastes (overburden, waste rock, tailings); major inhibiting factors affecting successful reclamation; and procedures for planning reclamation have already been well documented by Down and



Reclaimed tailings pond for wildlife use at INCO mine site, Sudbury, Ontario
I.B. Marshall, Environment Canada

Stocks, 1977; Goodman, 1974; Goodman and Bray, 1975; Harwood, 1979; Hawley, 1972, 1977; Hutchinson, 1977; Lavkulich, 1977; Leroy, 1973; Montreal Engineering Ltd, 1975; Murray, 1977*a*, 1977*b*.; Watkin and Watkin, 1982; and Williams, 1975.

Generally, mining wastes that do not contain iron sulphide minerals can be revegetated (Hawley, 1972). The most important problems are with tailings disposal sites containing high levels of sulphur and sulphur compounds, and/or arsenic and arsenic compounds. Many of these problems have been identified in a study of sulphide mine wastes at mine sites in the Noranda, Timmins and Sudbury areas (Montreal Engineering Ltd., 1974). They are as follows:

"1. ***There is a wide range of variation in the major characteristics of the sites investigated and even within any single site the variation may be such that it would be impossible to apply uniform criteria for rehabilitation. The extent of the variability is demonstrated by an index of potential for acid formation which is based on the degree to which oxidation of sulphides has occurred and the total unoxidized sulphur in the tailings.***

2. ***The conditions encountered by plant roots in tailings are totally distinct from those which would be encountered in soils. Tailings have none of the adsorbative capacitites for cations that are possessed by the clays and organic matter of soils. The very complex laws governing the balance and uptake of nutrients and micro-nutrients in soils are most unlikely to prevail in tailings. As a result of this it may be more realistic to apply the results of research in hydroponics to the establishment of plants, rather than to attempt to rigidly apply the criteria more closely associated with soil science.***

3. ***The uptake of nutrients and heavy metals is not necessarily pH related, but appears to depend on the balance of ions in the tailings solution. The acidity of the ground solution alone may prove to be toxic although there is evidence that plants will continue to grow below pH3 which is considered to be the lower pH limit for plants growing in soils.***

4. ***Of the major nutrients required by plants only phorphorus occurs in sulphide tailings in quantities which might fulfill plant requirements. There are very large deficiencies of nitrogen and potassium in almost all deposits.***

5. ***Lead occurred in toxic amounts in plant tissues more frequently than any other heavy metal, but toxic levels of copper and zinc were also recorded. Deficiencies of copper were also recorded in plant tissues from some sites.***

6. ***Hard pans which occur at many sites are probably caused by cementing of particles by iron. There is no clear relationship between pan formation, the characteristics of the pans and the amount of iron in the tailings. These pans constitute a limitation to plant growth by hindering the vertical extension of the roots.***

7. ***The quantities of readily extractable heavy metals in these tailings suggests that the water contained in the ponds and dams is likely to be heavily contaminated.***

8. ***Simple capping of wastes does not constitute a permanent solution to the rehabilitation of highly acid mine tailings deposits since toxic heavy metals and salts may move into the new surfaces by capillary flow." (Montreal Engineering Ltd., 1975).***

Approaches adopted to reclaim metallic mine wastes are now generally following three broad directions or combinations of the three:

(i) Direct seeding of mine wastes utilizing agricultural limestone and fertilizers to ameliorate the poor site conditions.

(ii) Incorporating soil amendments directly into the waste substrate (organic matter, innocuous waste, topsoil, sand, clay or glacial till overburdens, etc.) or as a capping on the surface.

(iii) Acceptance of the poor site conditions as they are and trying to revegetate with species having a high tolerance to these adverse conditions. This includes experimenting with and developing sources of native species with high tolerances to acidity, alkalinity and/or metals.[19]

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[19] Toxicity may be plant species dependent, hence, not all metals would be toxic (phytotoxic) to all plants.

Considerable experimentation and advocacy of the first method is prevalent in the metallic mine industry. The use of applications of overburden to various depths is usually a technique of last resort, or when easily available low cost sources of innocuous material are available. The first two methods have relied heavily on the introduction of readily available agronomic plant species. The third approach is usually adopted after the first two have been attempted, generally through the observation of native species that have voluntarily established on the sites. More and more, the procedure for the third approach is to devise a revegetation program which combines aspects of both native species and assisted or successional planting by initially stabilizing the site with a rapid growing cover species and then artificially preparing sites for native species (Harwood, 1979).

The first successful reclamation of sulphide tailings was by the International Nickel Company of Canada (INCO) in the mid-1960s after almost two decades of investigation (Peters, 1978; Watkin and Watkin, 1982). INCO developed a method of direct seeding using amendments of agricultural limestone and fertilizer to ameliorate the poor site conditions. The INCO tailings had a low iron sulphide content, since most of the acid generating pyrite and pyrrohotite was removed during ore processing. In the mid-1970s, the company initiated plans to develop a wildlife management area on the tailings utilizing trees that had established voluntarily. Trees voluntarily migrating into the tailings included birch, trembling aspen and willow. Experimental planting with jack pine and white spruce has been the most successful (Peters, 1978). Part of this program included tests on heavy metal uptake by waterfowl, mammals, and insects inhabiting the reclaimed tailings areas.

Falconbridge Nickel Mines Ltd. research at its Nickel Rim Mine led to the use of overburden cappings as the most promising method of achieving a maintenance-tree vegetative cover on the tailings (Michelutti, 1978). The acid tailings were characterized by a pH range of 2.5-3.0, high heavy metal concentrations, and a hard pan in the upper 5-60 centimetres due to the high pyrrohotite content. The ideal overburden was found to be a 7.5 centimetre layer of coarse material (.65 centimetres crushed slag) overlain by 7.5 centimetres of loam. The large spaces between the coarse overburden fragments acted as an effective barrier to the upward pore water migration from the tailings. In addition, it provided sufficient moisture retention and a cation exchange base for the vegetation. The cost of using overburden is quite high, and largely dependent on available sources close by. In the Falconbridge Nickel Rim project, supplies of sandy loam were within 1.5 kilometres of the site, thus reducing the cost down. Even so, overburden placement accounted for $660 of the total operational reclamation costs of $1,190 (in 1975 $). The costs would have been considerably higher if the source was further away.

Surface stabilization of iron ore tailings areas at Wabush Mines, Labrador began in 1970, but until recently were not successful (Horner, 1981). The tailings piles are extremely large, 60 to 100 metres high and consist of coarse quartz sand which dries quickly and is easily wind blown. Although non-toxic they are devoid of nutrients. Two revegetation approaches were adopted: direct seeding into the tailings, and into a peat tailings mixture. Due to the close proximity of peat bogs it was practical and economically feasible to place a layer of 15 centimetres of peat on the surface of the tailings.

In 1979, both surfaces were then subjected to the same fertilizer and seed applications. The surfaces were first broadcast with 500 lb/ac of 15-15-15 fertilizer, then 500 lb/ac of fall rye seed which was tilled into the ground with a disc-harrow. Next it was broadcast with a 83 lb/ac mixture of birdsfoot trefoil, (40%) timothy (30%) and perennial ryegrass (25%), with 1 lb of birdsfoot trefoil inoculant. In the next two years 200 lb/ac of the same fertilizer were applied in the spring.

The same seed mixtures and fertilizer rates were applied to the slopes of the tailings dykes, except they were applied by a hydro-mulcher with 1000 lb/ac of wood fibre mulch. The slopes were pre-conditioned with a klod-buster. In the final analysis, direct seeding may prevail due to the high cost of spreading the peat, despite its proximity. Timothy and winter rye appear to be the most successful species.

Recent attempts by ASARCO to reclaim sulphide tailings at its Buchans Mine in central Newfoundland have been successful in establishing a self-sustaining cover which has attracted grazing wildlife (O'Brien and Neary, 1981). The tailings with a pH range of 5 to 7 contain high levels of heavy metals and large quantities of the mineral barite. Since, the tailings contain little free sulphide minerals which would be major acid generators, reclamation has been possible with the use of lime.

A summary of the procedures and application rates of fertilizers and seed reported by O'Brien and Neary (1981) is listed below:

(i) 1200 lb/ac of 10-20-20 fertilizer with 0.2% boron were spread. Boron was used to help improve the growth of birdsfoot trefoil.

(ii) Seeding of a mixture of Italian Ryegrass at 15 lb/ac and creeping red fescue at 40 lb/ac. Spread at half-rate amounts in cross direction to ensure an even distribution.

(iii) Seeding of Empire birdsfoot trefoil at 20 lb/ac. Being smaller and heavier, it would not spread evenly if mixed.

(iv) The entire area was raked and then compacted with a roller.

(v) 1000 lb/ac of agricultural lime was added for plant nutrients.

(vi) In the following year 500-600 lb/ac of 3-18-18 fertilizer with 0.2% boron was applied. In July, 200 lb/ac of ammonium nitrate was added.

The cost of establishing a permanent cover on 22 hectares (55 acres) of tailings came to $2,015/hectare ($815/acre).

Concern that the revegetated tailings might pose a hazard to grazing wildlife resulted in the Canadian Forestry Service evaluating the revegetation experiments to qualify heavy metal uptake by the plants (Sidhu, 1979). The Forestry Service concluded that the concentrations of heavy metals in foliage grown on the tailings were well within reported limits in healthy foliage of firs and spruces in Newfoundland. Although this was not a problem, the report did point out that wind blown dust rich in heavy metals accumulated on vegetation and could be ingested by herbivores, posing potentially hazardous conditions.

During the course of its research the Canadian Forestry Service identified several natural species which had colonized on seeded tailings areas and it was subsequently reported by ASARCO that they were continuing to spread naturally (O'Brien, 1981; Sidhu, 1979). They were: clover, watergrass, horsetail, alder, willow, red top, fireweed, bullrush, pearly everlasting daisies, birch and scent bottle orchid.

Noranda Mines Ltd. (Horne Division) initiated a joint research program with the University of Guelph in 1974 to devise reclamation methods for copper tailings areas containing iron sulphides, pH range between 1.5-3.0 (Marshall, 1980; Watkin, 1980; Watkin and Watkin, 1982). Growth room and field studies evaluated several amendments including: agricultural limestone, rock phosphate, dust from cement and phosphate fertilizer manufacture, anhydrous ammonia and fly ash. Agricultural limestone provided the most consistent amelioration, despite considerable variation in application rates due to physical and chemical site characteristics. This variation reflected several factors:

> **"such as iron sulphide type and quantity, degree of oxidation of iron sulphides, distribution of tailings grain size in the tailings ponds, length of innundation of water on tailings surface, and mineralogical composition of the ore body" (Watkin and Watkin, 1982).**

Watkin and Watkin (1982) contend that it is impossible to conduct small plot trials in the field in order to determine plant growth potential because of the wide variation in tailings composition. The tests would take a minimum of 18-24 months to complete, or up to 3-4 years should additional factors such as seeding methods, mulches and rates of application need to be evaluated. Instead, the authors have suggested that a standard form of plant assay test be adopted to determine the agricultural limestone requirements necessary to sustain plant growth on a tailings area. "The basis of this technique is to take samples from a tailings area, then sample the selection being governed by visible variation on the tailings surface such as colour (degree of oxidation), particle size, and different moisture levels" (Watkin and Watkin, 1982). While admitting the technique is subjective, they suggest its advantage lies in reducing field testing time to less than 6 months, and concentrating on determining optional agricultural limestone and fertilizer requirements.

Tests by Noranda also determined that fertilizer, particularly phosphorus, was essential for vegetative growth on the tailings. The minimum requirement identified was 1680 kg/ha of 5-20-20. Nitrogen fertilizer was kept to a minimum due to the common ingredient in the seed mixtures being birdsfoot trefoil (*Lotus corniculatus*). High nitrogen levels reduce the rate of establishment of birdsfoot trefoil due to the competition effects of grass species included in the seed mixtures (Watkin, 1980).

Watkin and Watkin (1982) in their assessment of tailings reclamation in eastern Canada indicate that birdsfoot trefoil has become the cornerstone of all successful reclamation programs for acidic, neutral and slightly alkaline tailings. They also pointed out that other legumes, including alfalfa, and red, white and alsike clovers commonly used in past reclamation work do not provide the self-sustaining and maintenance free aspects of birdsfoot trefoil. Birdsfoot trefoil appears to adapt to the wide variety of tailings moisture conditions and it is winter-hardy in most of the country.

Watkin and Watkin (1982) identified a number of continuing reclamation problems common to eastern Canada. The Noranda research program confirmed the unreliability of agronomic "soil based" analytical procedures. By using plant growth as an indicator of agricultural limestone requirements, tests revealed that great variations can exist both within and between tailings disposal areas. The variation could not be correlated with the pH values obtained. They suggest that pH should be used only as a broad indicator of the presence or absence of potential problems in the establishment of vegetation cover. In addition, Noranda identified problems with the quality of agricultural limestone. Evaluation of a number of agricultural limestones in 1980-81, indicated that wide variations are common in their physical and chemical compositions as well as in their efficiency as neutralizing agents (Watkin and Watkin, 1982). Therefore, before their use some consideration must be given to their characteristics.

Overall, Watkin and Watkin (1982) concluded that the last 10 years of reclamation research on acid sulphide tailings still had not provided an understanding of the factors affecting plant growth, in chemical and biological terms. But, they did confirm that knowledge currently available can enable an operator to reduce or avoid costly, repetitive and unsuccessful reclamation programs.

In the mid-1970s Blakeman (1976) conducted investigations of the vegetation and physical/chemical environments at 13 different abandoned tailings disposal sites in eastern Ontario and southwestern Quebec, and a native species seeding program at Hilton Mines. The objective was to identify those native species which demonstrate a tolerance for the harsh physical/chemical conditions in a variety of tailings deposits. Blakeman (1976) identified several species on the basis of pH values which appear to be able to tolerate more acid or alkaline environments. They are identified below:

	pH 3.1-5.0	pH 9.1-11.6
Grasses	Red top	Quack grass
	Poverty grass	Kentucky blue
		Foxtail barley
		Alkali grass
Legumes	Alsike clover	White sweet clover (pH 9.1)
	Hop clover	
	Vetch	
Trees & shrubs	Quaking aspen	Quaking aspen
	Balsam poplar	Balsam poplar (pH 9.1)
	White birch	American elm (pH 9.1)
	White pine	
	Red spruce	
	Red raspberrry	
	American bass	
Herbs	Field horsetail	Dandelion
	Bladder campion	Bladder campion (pH 9.1)
	Early goldenrod	Early goldenrod (pH 9.1)
	Blueweed	
	King devil hawkweed	
	Silvery cinquefoil	
	Yarrow	
	Pearly everlasting	

Like Watkin and Watkin (1982), he stated that pH could only be used as an initial indicator, and that many other factors determined final acceptability.

Species planted in slightly alkaline but nutrient and moisture deficient test plots included:

- White Sweet Clover
- Fireweed
- Canada Blue Grass
- Bladder Campion
- Blueweed
- Milkweed
- Lambs Quarters
- Poverty Grass
- Mullein
- Canada Goldenrod
- Russian Thistle
- Red Top Grass
- Silvery Cinquefoil
- American elm

From field experiments, a combination of crushed rock and sawdust was most effective in increasing moisture content of the tailings and Russian thistle was the most successful species, exhibiting a high rate of germination and the most widespread distribution of well developed plants.

Seedbed preparation in progress at INCO site, Sudbury, Ontario

For those who wish to develop a native species revegetation program on metallic mine tailings, the Blakeman thesis and work conducted by the Botany Department/Institute of Environmental Affairs, University of Toronto should provide a most useful starting point in terms of literature review, methodology, and research design. Work conducted by the University of Toronto is discussed in the following section entitled "North of 60°".

An example of the reclamation research being conducted at metallic mine sites in British Columbia is the work being done by Cominco Ltd. (Gardiner, 1974, 1977, 1981; Gardiner and Stathers, 1979). Cominco Ltd. has adopted variations of two basic techniques to reclaim waste rock dumps, iron and siliceous tailings. The techniques include (Gardiner, 1981):

(i) Liming, then seeding with a legume grass mixture and applying fertilizer to aid vegetation establishment and sustain growth.

(ii) (a) Covering waste rock with a shallow layer of glacial till overburden, seeding with legume-grass mixture and applying fertilizer to aid vegetation establishment and sustain growth.

(b) Covering tailings with either glacial till overburden or less toxic wastes including float rock and gypsum, a solid waste produced during phosphoric acid manufacture at Cominco's fertilizer operations.

The waste products of Cominco's Sullivan concentrator (float rock, siliceous and iron tailings) are still deposited in active disposal sites, thus operational scale reclamation is some years away. But a program to reclaim the siliceous and iron tailings areas has been in progress since 1973. Due to the very high pyrrohotite content of the tailings (iron tailings, 48% Fe; siliceous tailings, 19% Fe) progress has been slow. The weathered siliceous and iron tailings have a pH in the range of 2.0 to 2.8. Extreme acidity is soon generated following disposition and exposure to the atmosphere. Studies by Cominco Ltd. have demonstrated that the liming requirement of siliceous and iron tailings is extremely high relative to normal soils and bears no relationship to tailings pH (Gardiner, 1981). This bears out similar conclusions about acid generating sulphide tailings in eastern Canada (Watkin and Watkin, 1982). In addition, oxidation has resulted in surface crusting and the formation of hard impermeable layers at or near the surface. On the iron tailings the impermeable iron oxide bearing layers are up to 7.5 centimetres thick, generally at or within 30 centimetres of the surface. Incorporation of lime into a potential "root zone" is effectively prevented by these layers. The siliceous tailings do not have the same physical problems.

The acid waste rock dumps (pH 2.5-4.5) are devoid of organic matter, deficient in plant nutrients, and have elevated levels of extractable metals which would be available to plants. On one area 6-7 tonnes/hectare of agricultural grade hydrated lime and dolomitic limestone were incorporated into the upper 15 centimetres. On a separate area glacial till overburden was spread to depths of 7.5, 15 and 30 centimetres. Seed mixtures on both tests included birdsfoot trefoil, orchard grass, creeping red fescue and hard fescue. In addition, tall wheat grass was used on the limed test areas, and red top on the overburden. Both tests were fertilized prior to seeding with 50 kg/N, 250 P_20_5 U, 100 kg/K_20 per hectare.

After three growing seasons, vegetative growth and metal content in the plants were similar for the two methods tested. Preliminary results suggest that 15 centimetres of overburden may be adequate to sustain a grass cover. Continued monitoring revealed no acid salt contamination of soils above the contact with the waste rock. The initial liming raised the pH to 5.6 but it declined to 5.0 after three years, suggesting that more lime may be required. Annual applications of fertilizer sustained a dense grass cover dominated by orchard grass. When discontinued, birdsfoot trefoil became the dominant species. Initial attempts to establish woody plants (silverbirch, lodgepole pine, western larch, douglas fir, black cottonwood, and kinnickinnick) were not successful. But removal of the herbaceous cover, resulted in substantially better results on limed experiments. The estimated cost of covering the waste rock with overburden was $4,875/hectare compared to $1,900/hectare to spread and incorporate the lime. Cominco estimates that the lime requirements of 50 tonnes/hectare could be applied and still be cost competitive with applying 15 centimetres of overburden (Gardiner, 1981).

Liming experiments on iron and siliceous tailings used the same procedures. Liming rates of 10, 200, 300 and 400 tonnes/hectare were applied in 1978. Fertilizer was applied in the following spring at 50 kg/N, 500 kg/P D2 U0 D5 U, and 100 kg K D2 U0 per hectare. Maintenance fertilizer was applied afterwards. The grass seed mixture (100 kilograms/hectare) included tall wheat grass, crested wheatgrass, Canada bluegrass, hard fescue, creeping red fescue and red top. On the siliceous tailings a lower rate of 100 tonnes $CaCo_3$/hectare (15 centimetres) maintained a neutral to mildly alkaline reaction into the fourth year. A satisfactory grass cover developed and sustained itself for three years. A larger 1.5 hectare test site is being developed to pursue these favorable results.

Quite different results were obtained on the iron tailings. A very poor and spotty vegetative cover developed, but only on those areas on which lime was applied at rates above 180 tonnes/hectare. Lime application at rates of 90 tonnes/hectare, however, resulted in strongly saline tailings with a raised pH of only 3.4 for two growing seasons. Liming at 180 tonnes/hectare raised pH in the upper 15 centimetres of tailings to 7.4, but between 15-30 centimetres it remained at 2.3.

Glacial till overburden was applied to the siliceous tailings to depths varying between 15-120 centimetres. The tailings were fertilized, and a legume/grass mixture was seeded, followed by maintenance fertilizer applications. Results of the test indicate that a minimum depth of 60 centimetres of glacial till is required to sustain the legume alfalfa; with less than 60 centimetres of overburden the crested wheatgrass dominates. At less than 30 centimetres of overburden, the surface vegetative cover deteriorates and areas devoid of plants develop. Evidence also suggests that the overburden has been contaminated by acidic salts migrating upward from the tailings. The areal extent and degree vary with the thickness of the overburden layer.

Earlier experiments by Cominco Ltd. determined that float rock had to be placed on the iron tailings to provide a safe working surface which would support equipment spreading overburden or gypsum. In addition, the float rock provided a barrier to prevent contamination of the overburden soil from acids in the underlying tailings. A similar situation occurred at the Waite Amulet Copper Mine in Quebec where Noranda Mines Ltd. has had to spread non-sulphide gold tailings over very poorly drained areas in the centre of a tailings pond (Brooks, 1981; Watkin and Watkin, 1982).

Cominco Ltd. placed glacial till (30, 60 and 120 centimetres) directly on the acid tailings and on a .30 centimetre thick pad of float rock. A grass legume mixture was broadcast on the two areas, and then fertilized. A cover of alfalfa and crested wheatgrass became established on all thicknesses of overburden placed on the float rock. A similar cover established on 60 centimetres or more of glacial till placed directly on the tailings. The shallow 30 centimetre layer of glacial till resulted in a less dense and spotty vegetative cover, and in the zone of contact with the tailings a lower pH and increased salinity developed. Plant roots were found to grow to within 10 centimetres of the tailings contact, then to extend horizontally.

Cominco has followed up their initial program with a larger overburden- float rock and gypsum-float rock test program. Since the company has large amounts of gypsum available, it is being assessed as an alternative to glacial till overburden. Further tests are being made to evaluate mixtures of drought tolerant grasses and legumes, in addition to indigenous trees and shrubs.

Applied research and operational reclamation programs at metallic mine sites are still heavily weighted towards the direct seeding approach with amendments of agricultural limestone and fertilizer. In addition, exotic agronomic species are still the predominant choice for establishing a vegetative cover. There is, however, an increasing trend towards "successional or assisted" revegetation utilizing indigenous native species or those non-indigenous native species which have been shown to be tolerant to conditions inherent to specific tailings deposits.

The use of various soil amendments either incorporated directly into the waste substrate or used as a capping is attempted when materials are available or for cost comparison purposes, but is often rejected on an actual direct cost-basis. It appears that thin layers of overburden of less than 60 centimetres are not able to reduce or stop the oxidation of waste sulphide minerals nor to maintain a heavy stand of grass or legumes. However, it does not reduce the value of vegetative cover on mine wastes to help control surface erosion by wind or water, nor its value in helping to build up the edaphic qualities of the mine waste.

MINES NORTH OF 60°

The most comprehensive source of information on reclamation in the Yukon and Northwest Territories is an annotated bibliography and review entitled Revegetation Information Applicable to Mining Sites in Northern Canada (Peterson and Peterson, 1977). Published by the Department of Indian and Northern Affairs, it is intended for use by resource management officers or mine managers who are required to make policy decisions on where or if assisted revegetation is to be attempted on disturbances from mining activities.

Tundra Gold Mines Ltd., Mathews Lake, Northwest Territories, abandoned in 1968
John Reid, Environment Canada

The authors included many references to revegetation on non-mining disturbances due to the lack of published material on reclaiming mine sites in the north. Revegetation was interpreted to include both "natural" and "assisted". "Assisted revegetation involves one or more deliberate steps by man to encourage the re-establishment of vegetation on a disturbed surface; unassisted revegetation refers to natural re-invasion of plants onto surfaces that have been disturbed by either natural or man-made causes." (Peterson and Peterson, 1977).

The review of published materials dealt with: key "how-to-do-it" reclamation guide books available; whether or not assisted revegetation was a valid goal or not in the north; objectives and strategies for northern revegetation; special problems of tailings; choice of plant materials; and sources of seeds and planting stock. The bulk of the literature available dealt with general disturbances related to exploration, seismic lines, service roads, drill sites and pipelines.

Peterson and Peterson (1977) concluded from their review of the literature that:

(i) There is no guaranteed method of revegetating difficult sites and that even the most comprehensive revegetation studies in northern Canada involving six years work (non-mine site locations) have resulted in revegetation specifications that are only "preliminary".

(ii) Revegetation by itself is not a guaranteed solution for control of alluvial or thermal erosion. Materials handling in the engineering phases of mining are more appropriate to ensure slope stability.

(iii) The use of a rapid dense cover of agronomic grasses and legumes (exotic) remains questionable in the north, since it has been seriously questioned as a valid revegetation method for difficult sites or high alpine elevations in the south.

(iv) In general, the best results in revegetation will be achieved by methods that work with nature to reestabish native vegetation as rapidly as possible.

(v) The north is different primarily in the climatic limitations of botanical choices and in the relatively slower growth rates.

Some of the report's recommendations included:

- The need for more precise criteria to aid the decision whether assisted revegetation should be attempted on various kinds of disturbed areas in the Yukon and Northwest Territories.
- The need to determine the minimum amount of seed and fertilizer to encourage natural colonization of disturbed areas.
- More detailed information on the ecology and physiology of northern shrubs and grasses is needed, particularly uprooted cuttings for revegetation programs.
- A commitment to provide long-term maintenance, management and follow-up assessment of revegetated areas should a commitment to undertake assisted revegetation be taken.
- Plant materials centres need to be established in the north to overcome shortages of seeds and other materials for planting.
- Outdoor laboratories at former mining sites are needed to establish long-term studies of ecology and evolution of naturally invading plant species.

Actual research programs designed to reclaim mine sites in the north have continued to be quite limited since the publication of the Peterson and Peterson review. The discussion which follows focuses on the recent trend of research at mine sites in the north to emphasize the use of native species to overcome mine wastes which are highly acidic, with heavy metal levels which may be toxic to some species. Investigations at Discovery gold mine, on the western shore of Giauque Lake, northwest of Yellowknife indicated that several stages of natural plant succession had occurred since the mine closed in 1968, but large sections still remained barren and subject to erosion (Taylor, 1976; Taylor and Gill, 1974). It appears that inclusion of some organic matter such as old mine timbers, stumps and brush, ash and animal waste provided the foothold needed for plants to colonize the tailings. Plant species were able to colonize in areas where the depth of the tailings was less than half a metre above the original ground surface. Species identified included: foxtail barley (***Hordeum jubatum***); fireweed (***Epilobium angustifolium***); slough grass (***Beckmania syzigachne***); several species of horsetail (***Equisetum arrense, E. fluriatile,*** and ***E. sylvaticum***); cottongrass (***Errophorum angustifolium***) and a sedge (***Carex aquatilis***). The main factors identified as inhibiting revegetation are soil acidity and associated metal toxicity; lack of plant nutrients; surface crusting; surface instability; and drought.

Research was initiated by the Department of Indian and Northern Affairs on abandoned tailings ponds at Arctic mine and Venus mine near Carcross, Yukon with the view to determining whether or not tailings could be revegetated (Bayne, 1975). At Arctic mine vegetative growth was not achieved due to the extremely low pH (2.0-2.3) and very high sulphuric acid content. Attempts to raise the pH level would require too great an amount of lime.

Conditions at the Venus mine were more favourable due to the higher pH of the tailings (7.0-7.2). Growth limiting factors in evidence were low nitrogen, phosphorus and potassium levels and moderate to high salinity. Field work on the Venus tailings indicated that revegetation could be undertaken by applying a seed mix containing slender wheatgrass, creeping red fescue, smooth bromegrass, climax timothy, and inoculated trefoil at 100 lb/acre. For maximum growth an application of 100 lb/acre nitrogen, 300 lb/acre phosphorus and 100 lb/acre potassium was suggested. Further fertilizer applications were recommended to maintain nutrient levels until organic matter built up. In the long run, the author suggested that limited liming in conjunction with carefully selected acid tolerant (native) species would be the best approach to the extremely high sulphide tailings.

In 1976, the Department of Indian and Northern Affairs, Arctic Land Use Research (ALUR) Program funded the Department of Botany and the Institute for Environmental Affairs, University of Toronto to select and field test easily propagated native species adaptable to northern latitudes which can tolerate long-term soil acidification and toxic levels of heavy metals in mine tailings (Hutchinson, 1977; Kuja and Hutchinson, 1979).

In adopting this research approach it was hoped that native species could be identified that require minimal amendments to the tailings and would have a good chance for long-term survival. Native species were selected from a very acidic soil environment (pH 2.0-3.0) at the Smoking Hills area of Cape Bathurst, N.W.T. The high acidity was the result of intensive SO D2 U fumigations produced from spontaneous burning of bituminous shales. Normal tundra soils in the area had a pH range of 7.0-7.5. Metals such as Al, Mn and Fe were readily available for plant uptake due to the low pH, of the soil water.

Mature plants of the grasses ***Arctagrostis latifolia***, ***Hierochloe alpina***, the sedge ***Carex bigelowii*** and the sage, ***Artomisia tilesii*** were collected from this site. In addition, seed of the grass ***Deschampsia caespitosa*** from the Sudbury smelter region was utilized, since it has rapidly colonized acid sites contaminated with heavy metals. Seed from a wild barley, ***Hordeum jubatum***, common to Yukon roadsides and some tailings sites was also included.

Tailings were collected for greenhouse trials from sites in the Yukon, including Arctic Gold, and Silver and Venus mines, and two abandoned arsenopyrite dump sites near Carcross. Tailings were also obtained from United Keno near Mayo, Cyprus Anvil at Faro (mines producing silver-lead-zinc and lead, zinc mines respectively with iron pyrite tailings) and Whitehorse Copper near Whitehorse. In the Northwest Territories, tailings were obtained from Pine Point (lead-zinc mine) on the north shore of Great Slave Lake, and Canada Tungsten. In Ontario, samples of iron pyrrohotite tailings were obtained from an abandoned site at Nickel Rim; in the Sudbury area.

In addition to greenhouse experiments, field trials were conducted on tailings at the Nickel Rim site in 1976, and at Cyprus Anvil, Arctic Gold and Silver, Venus and Whitehorse Copper starting in June, 1977. Plants of ***Arctagrostis latifolia***, ***Artemisia tilesii***, ***Carex bigelowii*** and ***Hierochloe alpina*** were transplanted. No amendments were made to the tailings. In July, 1977 treatments consisting of fertilizers, peat, crushed limestone and sawdust mulch were set up on the four Yukon sites. Seed of ***Deschampisia caespitosa*** and ***Hordeum jubatum*** were used and reseeding took place at the end of the summer of 1977. In May of 1978, plots at Nickel Rim were set up and seeded with ***D. caespitosa***, with amendments of limestone and fertilizers. Additional plots were also established at the four Yukon sites and sown with seeds of ***D. caepitosa*** and ***H. jubatum*** and amended with higher rates of limestone and peat moss.

Preliminary results of the field trials indicated that each of the six species showed potential on at least one of the tailings. On the widest range of field conditions the ***Arctagrostis latifolia*** performed the best. Further work will be directed towards obtaining viable seed for this species.

No species could tolerate the high sulphur content of the Cyprus Anvil tailings (30-40% S by weight). Success on the other tailings was achieved when the pH was ameliorated. Moisture availability is a limiting factor to growth, but relatively low applications of organic (6-8-6% NPK) or inorganic fertilizers (10-20-10% NPK, 21-7-14% NPK) improved growth response where moisture was available.

Kuja and Hutchinson (1979) suggest the best approach at the Yukon site is to sow seed in the autumn, thus enabling them to stratify over the winter and take advantage of spring moisture. They further indicate that these native species could be a viable alternative to commercial species which are not acid or metal tolerant, and in need of higher nutrient requirements. Future research attempts will be made to select a breed of tolerant strains of the species used in the study.

Cominco Ltd. has conducted revegetation trials on test plots in the Northwest Territories at its Con mine in Yellowknife and at the Pine Point Mine (Gardiner, 1977). The tailings at the Con Mine are both acid and slightly to moderately saline, however, creeping red fescue, meadow foxtail, redtop, reed canary grass and crested wheatgrass were able to survive at least three years. The establishment of salt tolerant tall and western wheatgrass, cold tolerant arcta red, creeping red fescue and foxtail barley and a salt tolerant legume, birdsfoot trefoil, was believed to have been due to favourable early precipitation.

The thrust of future reclamation research in the north is likely to continue along the lines of obtaining native species which are tolerant to acid (or alkaline) and elevated heavy metal conditions, as well as the harsh climatic conditions. For general surface disturbances or waste without an acid or a heavy metal content problem, research being conducted on native grasses and shrubs in the foothills and mountains of British Columbia, Alberta and the United States should also consider the use of several of these species in the north.

OIL SANDS MINING

All of Canada's surface-mineable oil sands are located in northeast Alberta. The maximum potential area that could be affected by surface extraction of oil sands is approximately 230,000 hectares (Marshall, 1982). The currently practiced extraction processes, however, present several problems for reclamation, the greatest of which is the tailings disposal system. The tonnage involved in oil sands beneficiation processes and the amount of land required to dispose of the waste tailings far exceeds that required in other forms of mineral processing. The Syncrude plant alone is expected to have a final production of 125,000 barrels/day extracted from an initial oil sands feed of 231,000 tonnes/day. At the end of its 25 year life it will require a 22-31 square kilometre tailings pond. The liquid contents of the pond will consist primarily of millions of tons of sludge which has poor settling characteristics, and a high water content (69%) resulting in it retaining fluid characteristics. The sludge will be impounded behind dykes built of tailings sand reacting from 55 to 100 metres above ground level. Estimates of the time required for the sludge to solidify vary from hundreds to thousands of years (Alberta Land Conservation and Reclamation Council, 1982).

Factors complicating the successful reclamation of tailings and overburden materials are summarized below (Etter and Lesko, 1977; Fedkenhuer ***et al.***, 1980; Lesko, 1974; Rowell, 1977; Takyi ***et al.***, 1977).

(i) The climate in the northeast allows for only a short growing season and very little precipitation in the summer period. This increases the drought conditions on the inherently low moisture-holding capacity of the tailings.

(ii) The tailings have initially high soluble sodium values (toxic) due to the addition of sodium hydroxide during the extraction process. Leaching eventually reduces sodium in the tailings to nontoxic levels. The tailings have a high pH (8.0-8.5), inherently low nutrient content, an absence of organic matter and microbiological activity. Physically they have extremely low cation-exchange capacity, high bulk density, low moisture-holding capacity and are easily eroded by wind when the surface is dry.

(iii) The overburden materials are sandy in nature, but less erodable due to the presence of some clay, and a slightly better moisture holding capacity. They are neutral to mildly alkaline, occasionally highly saline with low organic matter and nutrient levels.

Techman Ltd. and Rheinbraun Consulting Gmbh (1979) reviewed operational problems and results of reclamation experiments and came to the following conclusions:

> ***"– All materials available in the Muskeg River area that might be used as components of prepared soil have some major physical and chemical qualities that would act as***

limitations to good plant growth. The objective, which could only be definitively met at the operational level, is to combine the materials in the most advantageous proportions.

- **Tailings sands as described in this study have no qualities that would act to improve either the physical or the chemical characteristics of the future growth medium. Only where amendments are dense and impermeable could tailings sands act to improve texture. Simply stated, tailings sand would appear to dilute the positive qualities of whatever other soil amendments were used.**
- **Present experience shows that a relatively thin layer of muskeg (15 cm) with intensive fertilization and maintenance appears adequate for short-term erosion control. Long-term erosion control providing greater choice in plant species for revegetation will require the addition of suitable overburden materials.**
- **The fact that the majority of rooting stops at the tailings sand and amended tailings sand interface indicates that only shallow rooting plants can be grown on such a thin soil veneer. Deeper-rooting grasses and trees must be provided with deeper soil (prepares soil) to achieve optimum growth and long term stability. Specific depths of soil to be used must ultimately depend on site specific criteria for end land use, physical and chemical properties, productivity and erosion control expectations and cost. A relatively deep prepared soil is necessary to prevent leaching of water and nutrients below the amended layer and thus below the depth of root penetration."**

Additional reclamation problems identified included: predation of rodents on tree seedlings; low survival of the tree and shrub seedlings due to competition from dense grass mats; and the question of how long will fertilizer amendments be required to maintain reclaimed areas especially dyke slopes. (Techman Ltd. and Rheinbraun Consulting Gmbh, 1979).

The reclamation objectives of the province include the development of techniques to establish a self-sustaining, erosion-free cover on tailings pond dykes and to return tailings sand storage and overburden dumps to productive forest (Alberta Land Conservation and Reclamation Council, 1982). Initially grasses, legumes and shrubs will be used for erosion protection. Soil amending materials including peat (muskeg) and mineral overburdens (clay tills, if available) will be added to develop the soil. The peat will add organic matter, increase cation exchange capacity and available moisture holding capacity, lower bulk density, and maintain pH near the neutral level. Clay till is the most desirable mineral amendment. In addition to the positive properties that peat contributes, it can reduce free drainage and improve nutrient deficiencies (Ca, K, Zn, Cu, Mn). Mined-out pits will be filled with tailings sand and reclaimed.

Applied reclamation experience to date by Suncor Ltd. (formerly Great Canadian Oil Sands Ltd.) and Syncrude Canada Ltd. has comprised growth chamber and field plot experiments, tailings dyke stabilization by revegetation, and some reclamation of associated disturbances (diversion channels, borrow pits, power line right-of-ways, etc.). This has resulted in the establishment of a vegetative cover on approximately 775 hectares by 1980.

Currently a joint Reclamation Research Program has been initiated by the Alberta Reclamation Research Technical Advisory and the industry's Oil Sands Environmental Study Group in order to pool resources and avoid duplication of effort. Three priority areas have been identified (Alberta Land Conservation and Reclamation Council, 1982):

(i) Selection and propogation of suitable trees and shrubs

(ii) Soil reconstruction, including soil properties and biological activity in disturbed and reconstructed soils.

(iii) Equipment development to overcome inadequacy of currently used tillage and application equipment.

A listing of current research projects is included in Table 9, Chapter 3.

As indicated above, previous research has documented that a better growth of plants can be obtained when peat and/or clay are added to the tailings sand surface to improve its moisture holding capacity and fertility. But, there is still the basic problem of how much and what kind of materials should be added to ensure successful reclamation. In 1977, Syncrude initiated a research program to find some answers to these questions, as well as to determine what plant species can be grown on tailings sand amended with various amounts and types of soil materials (Fedkenheuer, 1979; Fedkenheuer ***et al.***, 1980).

A well-drained sandy soil (Eluviated Dystric Brunisol) area of 0.2 hectares was stripped of vegetation and soil down to the C horizon. Tailings sand was spread to a depth of one metre over the well-drained medium sand base.

> **"The tailings sands surface was subsequently divided into a series of plots and then either 10 cm of mineral fines (clay), 20 cm of mineral fines (clay), 10 cm of native sand or 10 cm of lean tar sand was applied over the tailings sand. Subsequently 15 cm of peat was placed over each plot, 50 kg per hectare of nitrogen, phosphorus, and potassium fertilizer was applied and the soil was rotorated to a depth of about 30 cm. All amendments came from Syncrude's mine area." (Fedkenheuer, 1979).**

Late in July, 1977 the plots were seeded with a 11 kilogram/hectare grass legume mixture of crested wheatgrass (Agropyron cristatum), wheatgrass (***Agropyron violaceum***), cicer milkvetch (***Astragatus cicer***), smooth brome (***Bromus inermis***), hairy wild rye (***Elymus innovatus***), sain foin (***Onobrychis viçiaefolia***), big bluegrass (***Poa ample***) and white clover (***Trifolium repens***). Containerized tree and shrub seedlings were planted in August, 1977, and June and September of 1978. Species planted are listed below (Fedkenheuer, 1979; Fedkenheuer ***et al.***, 1980):

Shrubs

Alnus crispa (Ait.) Pursh.	Green alder
Amelanchier alnifolia Nutt.	Saskatoon
Arctostaphylos uva-ursi L. Spreng.	Bearberry
Betula pumila L. var. ***glandulifera*** Regel	Bog birch
Cornus stolonifera Michx.	Red osier dogwood
Elaeagnus commutata Bernh.	Silver-berry
Potenilla fruitocosa L.	Shrubby cinquefoil
Prunus pennsylvanica L.f.	Pin Cherry
Prunus virginiana L.	Chokecherry
Rosa acicularis Lindl.	Prickly rose
Salix sp.	Willow
Shepherdia canadensis (L.) Nutt.)	Canadian buffaloberry
Symphoricarpos albus (L) Blake	Snowberry
Vaccinium vitis-idaea L. var. ***minus*** Lodd.	Bog cranberry

Trees

Larix laricina (Du Roi) K. Koch	Tamarack
Picea glauca (Moench) Voss	White spruce
Piceae mariana (Mill.) BSP	Black spruce
Pinus banksiana Lamb.	Jack pine
Pinus contorta Loudon var. ***latifolia*** Engelm	Lodgepole pine
Populus tremuloides Michx.	Trembling aspen

Early results indicate that soil amendments added to the tailings do improve it. Peat considerably improved soil physical properties of the tailings sand, particularly available water capacity. Soil texture was improved to a loamy sand on plots amended with native sand and to a sandy loam on the other three treatments. Nitrogen, calcium and magnesium levels increased but phosphorus and potassium levels showed a decrease (Fedkenheuer, 1979).

On plots amended with lean tar sand the density of grass-legume cover decreased, but produced the highest survival rates for tree seedlings. The authors suggest that the reduced grass-legume cover appears to have made more moisture available to the woody seedlings (Fedkenheuer ***et al.***, 1980). They suggest that a reduction in the grass-legume seeding rate may further improve woody species survival rates. Most species of the containerized shrub and tree seedlings survived very satisfactorily over winter for most species. The highest species survival rates over the range of treatments were ***Amelanchier alnifolia***, ***Pinus banksiana***, ***Pinus contorta***, ***Potentilla fruticosa***, ***Shepherdia canadensis*** and ***Symphoricarpos albus***.

Two further studies outlined in the following discussion serve to illustrate research designed to improve biological activity in the tailings wastes. Experiments designed to monitor biological activity were conducted on oil sand tailings variously amended with inorganic fertilizer, sewage sludge, and feathermoss peat (Visser, 1982). Assessment of various biological parameters measured indicated that peat was the most effective in improving organic matter and nitrogen status. All three amendments significantly introduced or stimulated bacterial and actinomycete numbers in the sand in the two year study. The peat amended sands were the most effective in increasing the length of fungal mycelium. In a longer four year study peat was also the most effective in increasing microbial respiration (CO_2 efflux) and biomass C. No significant correlations between plant litter input, root weight and microbial biomass C were identified.

Syncrude Canada Ltd. initiated studies to overcome one of the major reclamation problems of tailings sand and waste spoils, their extremely low soil fertility (Dai *et al.*, 1982). Recognizing the importance of legumes as a nitrogen fixer, the study set out to identify and develop ways of improving legume performance. The study isolated strains of ***Rhizobium meliloti***, then compared each strain's infectivity and effectivity on alfalfa. From alfalfa (***Medicago sativa***) and sweet clover (***Melilotus alba*** and ***M. officinalis***), plants growing in the Syncrude Mildred Lake project area, 122 strains were isolated. The 12 best strains were compared with isolates from a commercial inoculant and with some other known strains of ***Rhizobium meliloti***. Most of the available commercial strains are produced for use in agricultural soils of the United States and thus would be suspect for use under harsher conditions in northeastern Alberta.

Results of experiments revealed that the commercial inoculant was below average in performance, whereas all of the twelve 'best' strains were well above average performace. By mixing the three best strains a Syncrude (SYN) inoculant was prepared and tested in pot trials. Pot trials were set up to examine the effects of nitrogen fertilization on the growth of inoculated alfalfa grown alone or in competition with brome grass. Alfalfa growth and competition with the brome grass was best when inoculated, particularly at low nitrogen fertilizer rates (25-56 kg N/hectare).

Results have been sufficiently promising enough that field trials were initiated in 1981 on the slopes of a tailings sand dyke at the Syncrude lease to evaluate the Syncrude inoculant (SYN) in comparison with two commercial alfalfa inoculants. Two different inoculation techniques were being evaluated, peat-based inoculation and Prillon coated seed inoculation. The field trials should provide better evidence on the relative merit of using locally isolated inoculum as compared to commercial inoculum.

After a decade or more of research, the problem is that even the best experts are still unsure what it will take to reclaim the oil sands. Even the most comprehensive review available of the technical problems associated with oil sands indicates that we do not now have the technology to reclaim the oil sands, but, advances in tailings disposal and mine operating techniques may lead to progress sometime in the future (Techman Ltd. Rheinbraun Consulting Gmbh, 1979). The Techman-Rheinbraun findings however, are at this time being reviewed by Monenco Ltd., in a study commissioned by the Alberta government and oil industry, because of many contentious definitions and standards outlined in its report.

COAL MINES

Enough experience, technology and planning procedures have been developed to make considerable progress in reclaiming coal mine disturbances albeit to varying degrees of success. In view of existing reclamation requirements in the coal producing provinces, concurrent reclamation and field research is now being conducted at all surface coal mines in Canada. Concern with the size and scope of coal surface mine disturbances is reflected in the number government funded research projects in the coal sector, 104 of 352 identified in this study (see Appendix 13). Of the 70 projects initiated since 1975, 59 were located in Alberta.

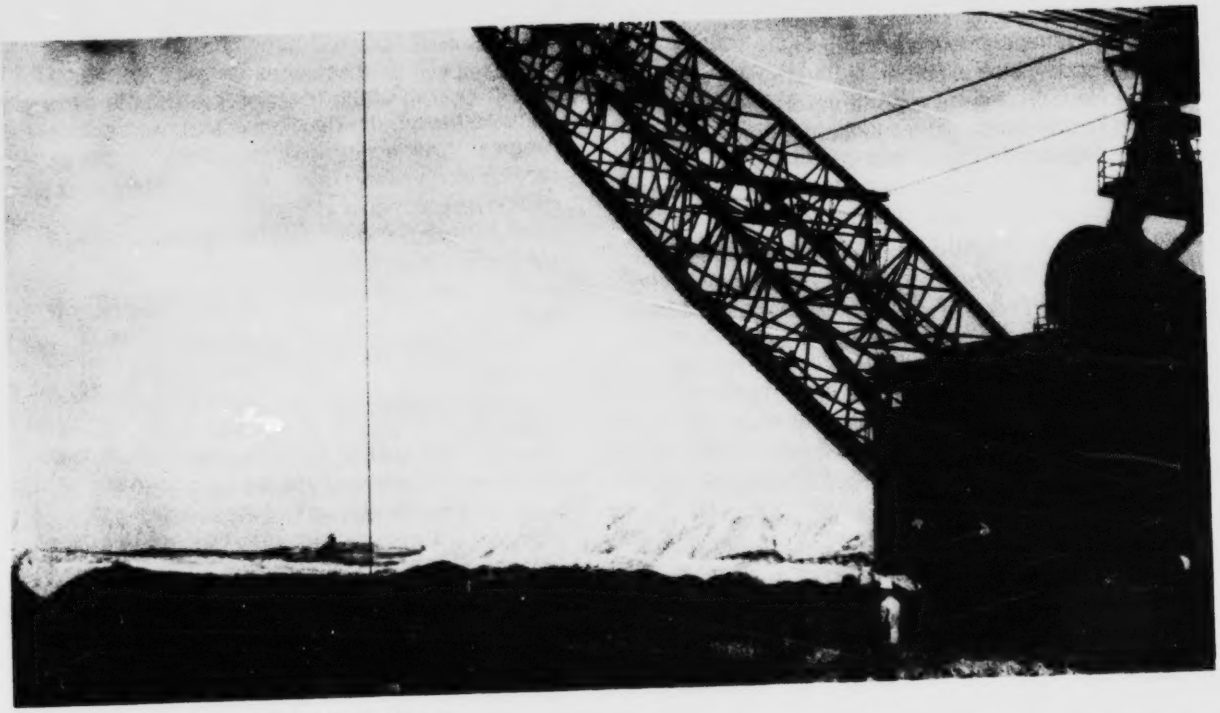
Reclamation practices are primarily directed towards surface extraction operations. Of the 18.5 million tonnes of coal extracted in the mountains and foothills of Alberta and British Columbia, 80 percent is from open-pits. Essentially all of the 18 million tonnes of coal in the agricultural plains of Alberta and Saskatchewan is extracted by strip-mining operations. In Nova Scotia and New Brunswick, 80 percent of 3 million tonnes is extracted by underground mines, resulting in relatively small spoil piles at the surface. The remainder is by surface techniques. As a result two major approaches to reclaiming coal disturbances have emerged, one for steep waste rock dumps in the western mountains/foothills region, and the other to reclaim the "ridge and furrow" topography created by strip-mines in the level plains of Alberta and Saskatchewan and the level terrain of the two Atlantic provinces. The main features of the two processes are outlined below:

a) Mountains and Foothills

During the extractive phase of open-pit mines the major problem is the handling and placement of million of tonnes of waste shale and limestone rock overburden in steep terrain. Disposition of mine waste rock for reclamation is included in the overall mine plan.

(i) At new or expanded mine sites topsoil and subsoil are normally stripped and stocked separately to be used later as topdressing in the reclamation process. (At older operations or abandoned mines, original soils are either buried or scattered by the time reclamation is initiated).

(ii) Operating practice is to dump waste rock in terraced outslopes in a wrap-around fashion as the mine is lowered. Slope angles usually do not exceed 26° (variations



Coal strip mining, using a dragline, Saskatchewan
W.B. Blakeman, Environment Canada

from 24° to 30°) in order to prepare a stable surface and minimize erosion. In some cases the incorporation of dump roads as terraces during resloping helps to reduce erosion and retain moisture for revegetation.

(iii) After grading or levelling of replaced topsoil (if any) revegetation is normally achieved by hydroseeding. Applications of fertilizer and mulch usually occur immediately before, concurrently with, or immediately after planting or seeding. Common practice in the region is the application of smaller annual quantities of maintenance fertilizer.

More complete descriptions of current practices can be found in: B.C. Coal Ltd., 1981; Berdusco and Popowich, 1979; Harrison, 1974; Hubbard and Bell, 1977; Lesko, 1975; and Macyk and Stewart, 1977.

b) Level Plain

Usually site preparation in the plains region includes the following operations:

" (1) Clearing vegetation and removing topsoil during the summer months;

(2) Stockpiling and segregating the topsoil and subsoil removed from new or expanded stripping areas for use in dressing graded spoil piles;

(3) Seeding stored topsoil with grasses to control weeds and reduce erosion;

(4) Stripping unconsolidated and consolidated overburden with draglines and casting it into an adjacent cut;

(5) Monitoring the characteristics of the overburden to determine alkalinity, salinity, etc., which would inhibit plant growth if material of this nature was placed at the top of the spoil pile;

(6) Segregating if necessary, the alkaline or saline overburden and covering it with innocuous material;

(7) Diverting existing streams around mining areas and if necessary pumping ground water into diverted streams to maintain flows in instances where watershed catchment areas are disrupted;

(8) Grading and countouring spoil piles to slopes of 5°-15° or otherwise in a way which is compatible with the premined topography;

(9) Dressing graded, settled and weathered spoil with stored topsoil to a depth which is sufficient to support vegetation; and

(10) Backfilling, grading and countouring final cuts, to permit flooding as future open water habitats for fish and water fowl or water sources for range land users." (Blakeman, 1980).

Actual revegetation procedures differ from site to site depending on the proposed post-mining land use with respect to plant species, amendments and the time required to achieve desired goals. Maintenance practices commonly include refertilizing, and reseeding if necessary. Crop rotation with grasses and legumes may be required for up to 10 years for lands rehabilitated to cereal grain production. (Mickelborough, 1977; Shaneman, 1977).

More complete descriptions of reclamation practices on level terrain can be obtained from the following references: International Joint Commission, 1979; Mickelborough, 1977; Montreal Engineering Co. Ltd., 1978; Railton, 1977; Shaneman, 1977; Techman Ltd., 1977; Williams, 1981.

Although both approaches appear to be conducive to concurrent reclamation, the steep slopes, deep pits or open cuts, lack of soil, large surface areas to stabilize and harsher climate make reclamation in the mountains and foothills more difficult, costly and time consuming.

In all the coal producing regions there are a number of outstanding problems inhibiting the successful reclamation of individual mine sites. In the following sections these problems are identified and an indication of research currently being conducted to solve them is outlined.

ATLANTIC PROVINCES

In New Brunswick and Nova Scotia the bituminous metallurgical and thermal coals contain 2 percent to over 8 percent sulphur, consequently, the coals and even some of the waste rock have an acid producing potential. Thus increased acidity and heavy metal levels have the potential to cause water pollution problems and impede successful reclamation. In terms of surface area disturbed by coal mines, over 90 percent occurs in the Minto-Chipman region of New Brunswick (Marshall, 1982).

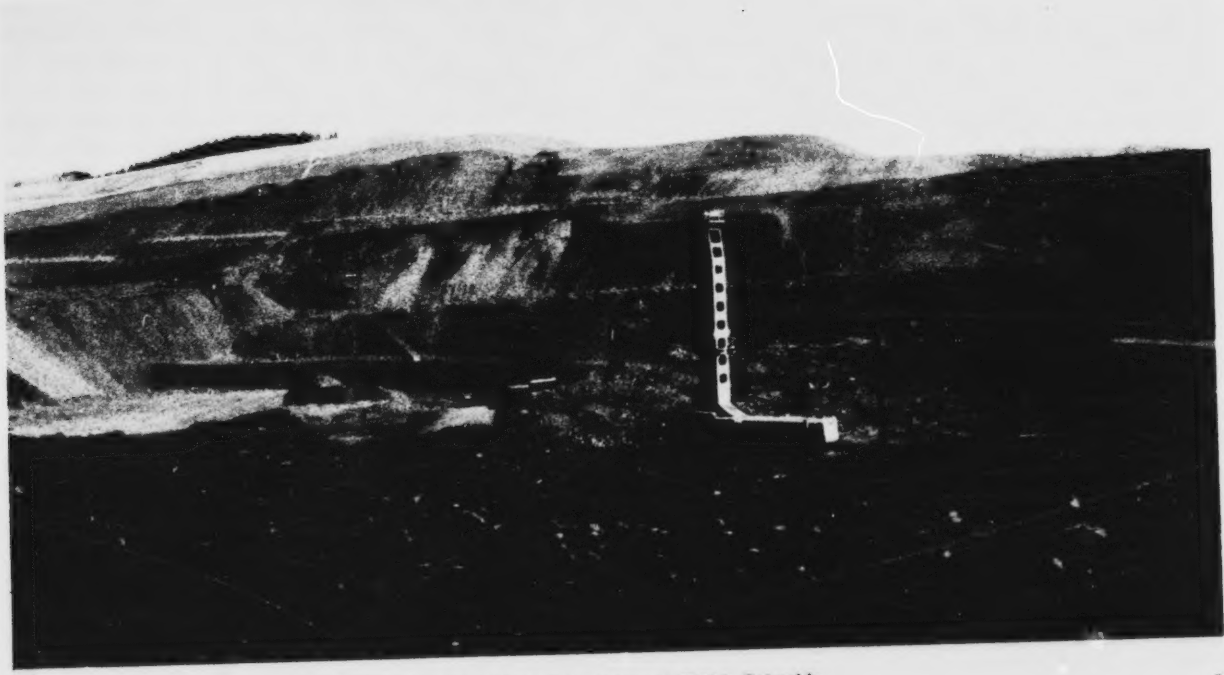
Past reclamation programs in the Minto-Chipman region have met with varying degrees of success due to: acidification of waste dumps due to oxidation of pyrite shales; low pH and related high solubility of heavy metal elements; poor moisture retention characteristics; low cation exchange capabilities; and a deficiency in essential nutrients (Abbott and Bacon, 1977; Montreal Engineering Ltd., 1978). Between 1967-1974, 1,860 hectares in the Minto-Chipman coal field were planted with a wide range of tree seedlings, and some slopes were graded and seeded with grass and legumes near main roads for aesthetic purposes. However, most of the area was not graded and steep slopes remained (up to 40° or 84% slope), resulting in serious slumping and loss of planted areas (Montreal Engineering Ltd., 1978). No toposil or glacial till was saved for topdressing during mining. The most successfully revegetated areas occurred on the less acid and shaley spoils, but generally grass and shrubs did not do well.

The most successful tree species utilized in the experimental tree plantings were Red Pine (***Pinus resinosa*** Art.), Scotch Pine (***Pinus sylvestris*** L.), Jack Pine (***Pinus banksiana*** Lamb.) and Black Louest (***Robina pseudoacacia*** L.). While dutch clover (***Trifolium repens***) was the most successful ground cover (Montreal Engineering Ltd., 1978). Some natural recolonization by white birch and trembling aspen has occurred in many areas.

Montreal Engineering Ltd. (1978) has presented detailed reclamation procedures and options for the New Salmon Harbour Midland coal strip-mine on behalf of the New Brunswick Department of Environment. They include the following aspects: mining/selective materials handling; physical surface improvement; soil conditioning; revegetation; and drainage control. Detailed reclamation options for commercial, recreational and agricultural post-mining land uses were given, in addition to recommended vegetative species and their characteristics (grass and legumes, shrubs, and trees).

Research and operational reclamation programs in Nova Scotia were started in 1975 by the Cape Breton Development Corporation with the view to reclaiming its

Reclaimed coal mine overburden spoils, B.C. Coal Ltd., Sparwood, British Columbia
I.B. Marshall, Environment Canada



Terraced overburden spoils at open-pit coal mine, B.C. Coal Ltd., Sparwood, British Columbia
I.B. Marshall, Environment Canada

strip-mines at Alder Point and Point Aconi, as well as abandoned mine sites at New Waterford and Donkin (Boutilier and Morton, 1978; Leydon, 1982). The main objective of the research trials was to determine suitable grass and legume varieties and soil amendments to reclaim coal mine wastes on Cape Breton. At the strip-mining sites topsoil had been stored and subsequently replaced, making the revegetation of the recontoured surface much easier. The best individual grass and legume varieties identified were: creeping red fescue, reed canary grass, tall fescue, Rubens Canada bluegrass, Brome grass, white Dutch clover and timothy (Boutilier and Morton, 1978). The best seed mixture included timothy (climax), perennial rye grass, alsike clover and red clover. Further research was conducted on additional species of grasses, as well as hydroseeding methods, seed mixtures, fertilizer rates for reclaiming wastes from old coal preparation plants and underground collieries. The reclamation of the old abandoned colliery sites at New Waterford by the Nova Scotia Department of Environment involved contouring, liming, fertilizer application and hydroseeding. Due to the more adverse physical and chemical conditions (lack of original topsoil and subsoil) 7 tonnes/hectare of agricultural limestone were used. A seed mixture of creeping red fescue, timothy, Kentucky bluegrass, aslike clover, tall fescue, annual rye and redtop was used (Leydon, 1982). Total cost of reclamation for the three New Waterford sites came to $1,250 per hectare.

MOUNTAINS AND FOOTHILLS OF THE CORDILLERA

The wide variety of biophysical conditions in the Cordilleran mountains and foothills creates a number of natural limitations, even before mining disturbances are accounted for. In general, the short cool growing season, summer droughts, erodible steep slopes, and naturally thin, nutrient poor soils create considerable initial limitations. The thin soils in general, particularly at higher elevations, make any selective materials handling difficult if not impossible. Only on the more subdued terrain and climate of the foothills are conditions improved significantly enough to allow for more successful reclamation efforts. The waste rock from mine operations forms long, potentially unstable slopes subject to slumping and erosion. The waste spoils are low in nutrients, organic matter and cation exchange capacity. In addition, alteration of natural surface drainage increases the potential for sediment loading and dissolved metal levels in local streams. This requires special reclamation diversions or culverts to be incorporated in the mining and reclamation plans. In a biological context, seed and plants of adapted native species are not readily available (commercially). Most commercial species are unadapted and collection of native seed is expensive. The low germination rate and vigour of native species also creates problems in obtaining sufficient quantities for reclamation purposes. In subalpine and alpine sites solutions are still being pursued on how to reconstruct a viable soil-plant system on mine wastes without indefinite maintenance requirements.

In order to find solutions to these problems, research is being directed towards the development of native plant species for high elevations; reconstruction of native soils if available or development of a viable soil growth medium on overburden waste dumps; development of initial cover crops to stabilize exposed slopes for erosion control and enhancement of successional revegetation.[20]

In British Columbia reclamation guidelines for coal mines require waste dump faces to be resloped to an angle of 26 degrees. In 1977, Fording Coal Ltd. initiated field tests to investigate optimal re-sloping techniques to be used in reclaiming their waste dumps. The objective of the slope study was to see if it could be demonstrated that steeper angles could be just as sussessfully reclaimed. The benefits being reduced material movement and less surface area to be reclaimed, and hence cost savings (Berdusco and Popowich, 1979). In addition studies were designed to compare vegetation growth on bare waste rock versus bare rock capped with glacial till. Earlier investigations in the Crowsnest Pass indicated that the biological angle of repose likes between 25 to 30 degrees which is 7 to 12 degrees less than the physical angle of response (Harrison, 1974). At elevations of 1,700 metres Fording re-sloped waste dumps from 37 degrees to slopes ranging from 24 to 34 degrees with various aspects. Calcareous glacial till layers, 15 to 30 centimetres thick were placed over portions of the wastes at angles of 26, 28 and 30 degrees, and then hydroseeded with a grass legume mixture.

Preliminary results indicated that operationally, waste dumps could be worked form 28 to 30 degrees, but slopes from 30 to 34 degrees resulted in cross pushing with low productivity and deep track markings. On slope angles between 32 to 34 degrees small circular failures occurred on isolated areas of fine wet materials. Glacial till eroded readily and large amounts of fines collected at the toe of 26, 28 and 30 degree slopes. Indications are that if sufficient fine soil particles are present grasses will establish on waste rock slopes up to 34 degrees. The average cost of re-sloping the waste dumps was $8,080 per plan hectare, (range from $4,670 to $10,750). However, after only a few years, it is still too soon to evaluate long-term stability of slopes and revegetative cover.

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[20] No attempt will be made to review the large number of research projects supported by the Alberta Government Reclamation Research Program in the mountains, foothills and plains regions of the province. Research priorities, individual and cooperative projects in progress are outlined in Table 9, Chapter 3 and Appendix 12. Current status and availability of interim and final reports can be found in the report, The Alberta Government's Reclamation Research Program – 1981 (Alberta Land Conservation and Reclamation Council, 1982).

In order to prescribe methods for reclaiming exploration disturbances in the Northeast Coal Block, the British Columbia Ministry of Energy, Mines and Petroleum Resources instituted a series of test plots beginning in 1976 (Errington, 1979). The programs set out to test: species germination, growth and survival under a variety of site conditions; fertilizer requirements and seeding rates; use of seed coated with micronutrients; and the difference between spring and fall seeding. The program identified a number of major problems for revegetation above the treeline, including: severe climatic conditions reducing the number of species available for use; high wind velocities; low nutrient values; and extreme variability in site conditions. Applications of fertilizer were required for successful survival of grass species in all instances, but seed coated with micronutrients did not appear to be useful in alpine situations. Available grass species which performed best in extreme alpine conditions are creeping red fescue (***Festuca rubra*** L.), climax timothy (***Phleum pratense*** L.), tracenta bentgrass (***Agrostis*** sp.), meadow foxtail (***Alopecurus pratensis***), and Kentucky bluegrass (***Poa pratensis*** L.). Most of the agronomic species are unlikely to be able to produce seed in the alpin conditions above the treeline. Although, only one site was tested below the treeline, it appears there will be no major problems using suitable agronomic species for reclamation. For large mine disturbances, the report concludes that native species will have to be relied upon to establish a permanent vegetation cover. Further work on natural succession is being conducted by the Ministry.

B.C. Coal Ltd.'s (formerly Kaiser Resources Ltd.) approach to reclaiming mine wastes has relied on the use of agronomic grass and legume species (B.C. Coal Ltd., 1981). Although continuing to support research and experimentation in the use of native species the company points out that there are still considerable gaps in the information available on requirements for growth and for seed stratifiction and progagation methods of native species. The approach adopted is to establish agronomic plant species at a primary level of succession and then through management accelerate the development of a self-sustaining plant community of grass and trees. Once the initial agronomic plant cover has been achieved then native shrubs and trees grown from seed or cuttings in greenhouses and nurseries will be planted.

As in the case of Fording Coal Ltd. (Berdusco and Popowich, 1979) the company at first re-sloped waste dumps to 26°, but as work progressed it appeared that underlying, and waste dump material would be stable enough to support angles up to 30° without surface creep or erosion. For three years these areas have successfully maintained their revegetated cover.

The suitability of using agronomic species over the long-term is still the major question. On revegetated sites below 1,675 metres (5,500 feet) agronomic species have established successfully, some without annual maintenance fertilizer for over three years, but test areas at higher elevations have not shown the same results (Ziemkiewicz, 1979). There is still no definite time limit on how many years of supplemental fertilizer will be required. The practice of using agronomic species has continued in the belief that they will develop a stable permanent vegetative cover.

Overall, research efforts to revegetate disturbances in arctic, alpine and subalpine areas have reported initial growth but poor persistence due largely to the withdrawal of fertilizer applications (Brown ***et al.***, 1976, 1978; Ziemkiewicz, 1979). Since, mineral nutrition is critical due to the depression of decomposition and nutrient cycling in cold climates, repeated fertilization is often required (Brown ***et al.***, 1978).

Ziemkiewicz (1979) set out to identify whether after three years, maintenance fertilization was still necessary on two reclaimed coal mines in the vicinity of Sparwood in southeast British Columbia, one in a Montane forest (1,600 metres) and the other in the Subalpine (2,100 metres). In addition, nearby undisturbed grasslands were examined to characterize stable grassland processes. "Sites were partitioned into shoot root; detritus and soil compartments to allow examination of the major pathways of intra and extra-plant nutrient exchange and storage." (Ziemkiewicz, 1979).

From these experiments, the author concluded that fertilization inhibited development of the Montane reclaimed area root systems by stimulating shoot growth during drought periods. Elimination of maintenance fertilizer on many of the Montane areas will shorten the time required to complete annual fertilization programs. Detrital inputs nearly matched losses indicating that decomposition was effective in maintaining the mobility of N and P. At reclaimed alpine and subalpine locations, plant communities may never become mature until adapted native species become established. Detrital decomposition was retarded in the subalpine areas resulting in accumulation of large amounts of N and P in unavailable form. Further research on native species in the subalpine area was recommended.

More recent investigations were conducted in the same area, an older reclaimed waste dumps at B.C. Coal Ltd., at elevations of approximately 2,000 metres with southwest exposures (Fyles *et al*., 1982). Research was directed at the continuing problem in mountainous areas that of determining the period of time required to continue maintenance fertilizer before a reclaimed area can be considered self-sufficient. Data from sampling plots ranging in age from unvegetated spoil (zero years) to six years old on slopes of 26° were used. On the reclaimed areas studied refertilization occurred each year at rates of 200 kg/hectare of 13-16-20 fertilizer. Results of the studies indicate that the revegetated slopes appear to be dependent on fertilization for up to five years. On the older reclaimed areas conditions were similar to undisturbed grassland soils, good shoot and root growth, soil CO_2 evolution, and available organic matter levels. The major difference between the native and older reclaimed soils was the available soil organic matter. The reclaimed soils still had lower levels of humic materials. However, the authors suggest further research should be conducted to provide a better understanding of the role of soil organic matter in the nutrient self-sufficiency of reclaimed sites and whether or not indigenous carbon and nitrogen in the wastes can be made available through weathering (Fyles *et al*., 1982).

A major thrust of research in the mountains and foothills of Alberta has been to identify and develop sources of native plant materials to reclaim mined or disturbed land at high elevations. Research to date under a native woody plant program has identified twenty-four candidate plant species for possible reclamation purposes (King *et al*., 1982). The woody plant species are listed in Table 19. Future research is aimed at evaluating the candidate species according to the criteria identified below and creating a short list suitable for field trials in the spring of 1983:

"1. Value in restoring mined or disturbed land to a productive, renewable land use.

2. Adaptability to sites which have been disturbed.

3. Ability to ameliorate disturbed land.

4. Ability to naturally increase or maintain itself.

5. Feasibility of large scale nursery or greenhouse propagation from seed." (King *et al*., 1982)

The evaluation phase includes the definition of site requirements for the various species and identifying the major limitations to the use of species in reclamation.

A program to identify native grass species began in 1974 at the University of Alberta with funding support from several Alberta government agencies. From an initial 37 species identified (Walker *et al*., 1977), 19 species were eventually evaluated in test plots for vegetative growth, ground cover and ability of species to reproduce (Sadasivaiah and Weijer, 1982). Native species identified for their superior ability to survive and reproduce under alpine conditions were ***Agropyron latiglume***, ***Agropyron dasystuchyum***, ***Agropyron trachcaulum***, ***Agrostis scabra***, ***Deschampsia caespitosa***, ***Festuca saximontana***, ***Festusca rubra***, ***Phleum alpinum***, ***Poa alpina***, ***Poa interior***, and ***Trisetum spicatum***.

Applications of peat mulch and fertilizer at the time of seeding has no effect on seedling establishment. Evidence from experiments and observations indicate that native grasses will take approximately three years before they reach maturity and that overseeding does not improve initial coverage. Test plots on shale slag at 1,980 metres (6,500 feet) indicated that native species were able to establish themselves, albeit with slow growth regardless of the poor soil conditions.

Other research programs are experimenting with various treatments of native grass seed mixtures and companion crops of cultivated grasses and legumes. (Tomm and Taki, 1982). The objective is to define seed mixtures that will produce an early erosion-controlling cover and eventually evolve into mature native plant communities. Initial results showed that up to the end of

TABLE 19. CANDIDATE WOODY PLANT SPECIES FOR RECLAMATION ON THE EASTERN SLOPES OF ALBERTA

SCIENTIFIC NAME	
Alnus crispa (Ait.) Pursh.	green alder
Alnus tenuifolia Nutt.	thin leaf alder
Amelanchier alnifolia Nutt.	Saskatoon
Arctostaphylos uva-ursi (L.) Spreng	bearberry
Cornus stolonifera Michx.	red osier, dogwood
Elaeagnus commutata Bernh.	silverberry
Juniperus communis L.	ground juniper
Larix lyallii Parl.	alpine larch
Pinus flexilis James	limber pine
Populus balsamifera L.	balsam poplar
Populus tremuloides Michx.	trembling aspen
Potentilla fruticosa L.	shrubby cinquefoil
Rosa acicularis Lindl.	prickly rose
Rosa woodsii Fendl.	Fendler woods rose
Rubus parviflorus Nutt.	salmonberry
Rubus strigosus Michx.	wild red raspberry
Salix barrattiana Hook.	willow
Salix bebbiana Sarg.	beaked willow, bebb willow
Salix glauca L.	grey willow
Salix planifolia Pursh.	willow
Salix scouleriana Barratt.	scouler willow, black willow
Shepherdia canadensis (L.) Nutt.	russet buffaloberry
Sorbus scopulina Greene	Green's mountain ash
Sorbus sitchensis Roemer	sitka mountain ash

Source : King et al. 1972.

the second growing season after seeding cultivated species did not significantly affect the establishment or growth of native grasses.

Recently the Department of Agriculture has proposed soil quality criteria for reclaiming disturbed land (Alberta Agriculture, 1981). For the Eastern Slopes region of the province the basic assumption is made that the amount of soil material replaced will depend on the amount available before mining. From existing research they indicate that a minimum soil depth of 15 centimetres is necessary and ideally up to 100 centimetres if sufficient quantities of suitable soil material is available. Criteria used to evaluate the suitability of the soil materials for use include depth (the initial qualifier), reaction (pH), salinity, sodicity, saturation, coarse fragments, texture, moist consistency and $CaCO_3$ equivalent.

PLAINS OF ALBERTA AND SASKATCHEWAN

Although considerable progress in reclamation has been made in the past decade, the technology is still young, particularly with regard to soil reconstruction and groundwater readjustments. It will probably take up to ten years or more to determine whether or not reclaimed areas are long-term successes or not (Shaneman, 1977; Williams, 1981). In 1980, there were 11 surface coal mines operating in the agricultural plains (5 in Alberta and 6 in Saskatchewan). Preplanned, concurrent reclamation is now practiced at all of them: in Alberta the average annual rate of disturbance is estimated at 105 hectares, and the average annual rate of reclamation between 60-130 hectares; in Saskatchewan the rates are 190-210 hectares and 140-190 hectares respectively (Blakeman *et al*., 1982). Relatively good forage crop yields comparable in quality

Overburden spoil piles at a coal strip mine being levelled for revegetation in southern Alberta
I.B. Marshall, Environment Canada

FLOW-DOWN
CLOVER

Revegetated coal strip mine in southern Alberta
I.B. Marshall, Environment Canada

and quantity to surrounding farmlands have been achieved at Lake Wabamun, and near Forestburg in Alberta (McAllister Environmental Services Ltd., 1979; Railton, 1979; Williams, 1981). In Saskatchewan, the very large backlog of mine spoils (increases of 4,500 hectares) has hampered progress, since at no time was the topsoil or subsoil salvaged in the Estevan area (Douglas, 1979). Large areas have very steep slopes with high levels of sodium and montmorillarite clays, resulting in strong compact or cemented surface crusts, that retard germination and growth of plants, and increases erosion and runoff (Anderson ***et al.***, 1975). On these older sites only shallow mine spoils free of sodium and clay inhibiting factors have been successfully reclaimed (Douglas, 1979).

Despite the current knowledge and progress made in reclamation there are several problems that continue to inhibit the overall materials handling and soil reconstruction process, the most costly component of reclamation. In the plains region of southern Alberta and Saskatchewan there is a soil moisture deficit under natural conditions, thus mining further aggravates this situation. But more importantly little is known about the effects of surface mining on groundwater. In many plains areas coal seams act as major sources of water. Thus more than just the soils must be restored in order that land can be returned to agricultural uses. Since changes in hydraulic properties and in filtration rates occur at the mine site, it is likely that changes can be expected in surrounding areas, particularly where ground water aquifers are concerned (Alberta Environment, 1980). Another factor potentially affecting groundwater can occur where coal ash from thermal plants is put in the bottom of a mine pit. Although, not part of the mining process, the potential use of coal ash in reclamation has been reviewed in a recent workshop. The workshop covered research related to its presence in dormant ash disposal lagoons, as a capping over orphaned sodic mine spoil or indirectly as an element in post-mining groundwater systems (Ziemkiewicz ***et al.***, 1981).

Another problem in reclaiming coal surface mines is the presence of saline and sodic spoil materials near the surface after mining. Large areas of the plains coalfields are overlain by parent materials derived from saline clay geological deposits. Both the saline and sodic spoils interfere with the ability of plants to absorb water and nutrients unless deeply buried during soil reconstruction. In addition, sodic materials tend to disperse clay particles, and under dry arid conditions they form hard crusts, which impede revegetation efforts and increase erosion by surface runoff (Anderson ***et al.***, 1975; Techman ***et al.***, 1977). Various methods of reclaiming saline and sodic soils have been known for some years, but their long-term effectiveness is still not fully accepted (Williams, 1981).

The reconstruction of a viable soil profile is still the major overall problem. Regulatory requirements demand that the reclaimed land be at least as productive as the original soil. In order to rebuild the soil, each soil layer must be removed carefully prior to mining, stockpiled carefully and later returned in the same order. But we do not know exactly how much capping material is required (Alberta Land Conservation and Reclamation Council, 1982). Recently, Alberta Agriculture (1981) issued proposed soil quality criteria for reclaiming disturbed coal mine sites in the agricultural plains, recommending that a minimum 300 centimetres (3 metres) of material be replaced if available. They identified three important depth zones within this replaced material.

(i) >15 centimetres topsoil; the surface "A" horizon

(ii) >100 centimetres subsoil; the "B" horizons and upper portion of the parent material to a depth of 1.5 metres.

(iii) >180 centimetres buffer; the material between the root zone and bedrock that has properties such that it may be used to maintain the quality of the replaced root zone.

As indicated in the section on mountains and foothills, criteria for evaluation of each of the topsoil, subsoil and buffer zones has been established.

The problem presented by these proposals is the cost of selectively handling the materials. Techman Ltd. (1977) estimated that minimum cost of selectively handling 30 centimetres of topsoil and 120 centimetres of subsoil in Alberta would be $14,825 per hectare. The Alberta Agriculture criteria requires three layers and twice the amount, thus it can be assumed the overall material handling costs would increase. It is important to know if these suggested depth requirements are really necessary or are there alternatives. Alternatives will have to be found where topsoil and subsoil are too thin or poor for reclamation purposes.

Another complicating factor in conducting research on soil reconstruction is that some factors cannot be properly represented in mining simulation experiments (Warner and Valleau, 1982). For example:

> ***"Because of variations in compaction between disturbed materials and undisturbed materials beneath and bordering the plots, the water table in the plots may not represent the probable situation on the reclaimed surface." (Warner and Valleau, 1982).***

In Saskatchewan experiments have been conducted on abandoned coal mine spoils since 1963, in order to find tree species which could be used for reclamation. Few trees grew naturally in the area to start with. (Flavelle, 1979). After years of experimentation, some trees and species can grow in selected sites, but levelling to stabilize the soil must be carried out first, for any quick rehabilitation success. In terms of survival, total height and vigor, Russian olive, Manchurian elm, hedge rose, Scots pine, willows (Pendandra, white, acute and black), and poplar (Grandifolia, Griffin, Northwest and Wheeler) were identified for use. Use of rooted stock for the willows and poplars was recommended. Successful grasses on levelled areas after four years growth were sweet clover, crested wheatgrass, Russian wild rye and Brome grass.

Most of the problems identified above in reclaiming coal mines in the agricultural plains of western Canada are currently under investigation by the Alberta Reclamation Research Technical Advisory Committee and members of the coal industry in a jointly developed research program, the highlights of which can be found in Table 9, Chapter 3. It is evident from this brief review that there are still considerable practical problems to successful long-term reclamation on the plains.

38. Bucket wheel excavator at oil sands site, Fort McMurray, Alberta
NFB — Phototheque — ONF, George Hunter

CONCLUSIONS AND RECOMMENDATIONS

REGULATORY REQUIREMENTS

Although there appears to have been some orderly progress in the development of regulatory requirements for reclamation in Canada, "state-of-the-art" approaches to reclamation are not being uniformly practiced across Canada. In fact, the federal and provincial governments have each followed their own individual path in attempting to resolve environmental problems in general and reclamation in particular.

This process has led to a wide range of enforcement concepts, ranging from specific acts and regulations which spell out detailed policy and guidelines, through those which present only general criteria, to those in which the reclamation requirements are determined under licence/permit, agreement or memorandum of understanding.

At the federal level, there is still no specific legislation requiring reclamation at mine sites north of 60°, nor elsewhere with the exception of special requirements for uranium mines under the Atomic Energy Control Board's jurisdiction. Any mine on federal lands within provincial boundaries follows provincial reclamation requirements. Unlike the United States, there is no nationally enforceable surface mine reclamation act.

Reclamation requirements in the Yukon and Northwest Territories are imposed through a series of permits or licences, and conditions of lease. Control of mineral exploration, mine development and operation requires: land use and prospecting permits; water use authorization or licence; land tenure agreement or lease; and, for new developments, an Environmental Assessment and Review depending on the circumstances (to date, no Environmental Assessment and Review Process has been applied to a mine).

The rapid expansion of placer mining operations in the Yukon has led to the development of new Placer Mining Guidelines, under the Northern Inland Waters Act, that include reclamation requirements, and new land planning and management mechanisms to contain future disturbances. They are to be released for review by the public and industry in the spring of 1983.

The federal Atomic Energy Control Board, through its authority under the Atomic Energy Control Act, has regulatory control over supply and licencing uranium mine and milling operations throughout Canada. It is currently developing new close-out regulations, but interim close-out requirements for each mine are written in the "licence" conditions in consultation with Environment Canada and provincial agencies. Additional conditions can be attached to the "lease" to use the land by the province, however, they cannot be less stringent than the federal requirements.

Provincially, the Alberta Land Surface Conservation and Reclamation Act is the only piece of legislation dealing exclusively with protection, conservation and reclamation of all types of surface disturbances, providing for a uniform procedure for reviewing and approving reclamation activities. The other provinces have increased environmental control and reclamation requirements at mine sites through the use of existing mining acts, new environmental assessments or broad environmental protection acts. An early exception is the Ontario Pits and Quarries Control Act (1971).

In the provinces there was initially an increased use of specific sector regulatory mechanisms rather than a universal act or set of regulations for the mining industry. This has been followed by an even greater use of guideline mechanisms for reclamation, prompted by the need for greater flexibility and more on-site decisions regarding reclamation plans by operators. The earliest specialized regulatory requirements were for "coal" and "aggregate" operations, mainly because of their more obvious and extensive surface disturbances. In Alberta, separate regulations have been issued for coal, oil sands and sand, gravel, clay and mine surface operations. In British Columbia, a new Mine Act has moved towards the Alberta approach and put the reclamation of all mining disturbances under the single act, with a special section for additional requirements pertaining to coal mines. Elsewhere in Canada, separate acts or regulations for aggregate pit and quarry operations have been established in all provinces except Saskatchewan. Separate requirements for coal mining are also present in Saskatchewan and under guidelines in Nova Scotia.

Abandoned cesium mine, Bernic Lake, Manitoba
NFB — Phototheque — ONF, Chris Lund

Until recently, mining acts in Newfoundland, Nova Scotia, New Brunswick, Quebec and Ontario have been ineffective in imposing reclamation programs, generally due to their weak nature and lack of enforcement. This situation has been changing in recent years with the transfer of responsibility for reclamation from Mining Acts to Environmental Acts or by joint jurisdiction in Ontario, Quebec, Manitoba, Saskatchewan, Nova Scotia and Newfoundland.

A major proportion of mineral aggregate production has taken place on privately owned land; and extraction from private lands has often been without restraint (particularly in eastern Canada) except for local municipal or regional government zoning restrictions and by-laws requiring reclamation within municipal boundaries. In some cases, municipal reclamation requirements are the only ones in force, owing to tenure and jurisdictional discrepancies.

Failure of early reclamation legislation to provide adequate controls on both private and Crown lands is being reassessed by most provinces, resulting in reclamation requirements being applicable to all lands.

There is a need to recognize that reclamation may not always be feasible and that the probability of permanent damage is high. Accordingly, innovative approaches and technologies may be called for in order to provide economically and socially acceptable alternatives to traditional reclamation requirements. Future decisions on the use of land may have to take this into consideration before allocating land to certain mining activities, at least until new technology provides solutions. If certain mine wastes cannot be reclaimed, then concepts of post-mining use — especially sequential or multiple use — may have to be abandoned, and those methods which allow for the highest or best post-mining use, based on socio-economic cost-benefit analysis, may have to be examined more closely. Around waste storage sites which have no prospect of alternate post-mining use, for instance, buffer zones may be necessary.

The most widely adopted means of obtaining comprehensive, multi-disciplinary control of new mine developments has been the adoption of Environmental Impact Assessment procedures, either through definitive acts and regulations or through the introduction of policy statements under the authority of other environmental acts. This has led to a rise in preplanning of environmental protection and reclamation procedures for all new mine developments or expansions to existing mines.

The means of enforcing Environmental Impact Assessment procedures and reclamation requirements is through the use of "conditions of permit approval" or "leases" on a site-by-site basis. The trend in this approval process has been to introduce Reclamation Review Committees with representatives from a wide number of involved departments and agencies. In most cases, the use of a single department (often Environment) or a semi-independent agency as the central coordinator is the norm. However, line departments (e.g. Mines and Energy, or Natural Resources) have maintained their former jurisdictions and traditional functions under older acts. This means that more than one licence, lease or permit will often be required in the mine approval process.

Two basic premises apply to new mine developments and often to currently operating mines (still operating after the introduction of reclamation regulations). First, mines should be prepared to accept constraints or conditions being attached to permits as conditions of approval. Secondly, they should be prepared for modifications in the conditions of a permit during the life of a mine operation. Standard enforcement mechanisms now include the posting of bonds or security deposits; filing annual reclamation reports; and annual field inspections by regulating agencies. Common regulatory requirements for reclamation, now include making the proponent responsible for costs; pre-operational development of reclamation plans; increased requirement for a designated post-mining land use; concurrent or sequential reclamation where possible; the immediate commencement of reclamation research; and the stockpiling of topsoil and subsoil for post-mining reclamation use.

Appeal of Environmental Impact Assessments and reclamation requirements lies with the responsible department, with final appeal to the Minister responsible. There is a great deal of ministerial discretion involved in the entire process, in an effort to provide for the uniqueness of each mine proposal.

In comparison to reclamation regulations in other countries, Canada is not over-regulated. Although it appears that formidable operational reclamation standards have been introduced within the past decade, they are not excessively demanding, and in many respects they are less stringent and rigid than nationally applied federal regulations in the United States.

RECLAMATION PROGRAMS

In the past decade there has been a considerable but unevenly distributed increase both in interest and support by different levels of government towards land reclamation in the mining industry. Some 352 projects have been identified as having government or university involvement either as direct involvement in research or as the coordinating or funding agency. In terms of regional distribution, two-thirds of the projects took place in the four western provinces. Fifty percent of all projects took place in Alberta, almost half of which dealt with coal mines. The Atlantic provinces, Quebec and Manitoba/Saskatchewan regions combined, accounted for less than 15 percent of the total projects. Thirty percent of all projects were associated with coal operations, 23 percent with revegetation studies applicable to all types of disturbances and 18 percent with metallic mines.

The federal government was involved in 128 projects, but only 30 of these were carried out by federal personnel alone. Provincial governments were involved in 191 projects, 149 of which were funded solely by the provinces. University researchers were involved in 111 projects, of which only 16 were based on non-governmental funding. Over 40 percent of the federally supported research was not specifically designed to deal with mining wastes; provincially, less than five percent of the projects fall into this category. Only 25 percent of the projects involved actual site reclamation. The high percentage of projects associated with general exploration disturbances and coal mines in British Columbia and Alberta is largely a reflection of early legislation and public pressure in the late 1960s.

FEDERAL

The federal government does not have an overall policy or research program of support for land reclamation. Almost all involvement to date has been in response to formal requests for assistance on specific problems, joint federal/provincial initiatives, or ***ad hoc*** advice. Exceptions have been in the uranium industry or where the federal government has an equity position. Five major departments and two Crown corporations have been involved in direct research or funding of reclamation research - Environment; Energy, Mines and Resources; Indian Affairs and Northern Development; Agriculture; Public Works; Atomic Energy Control Board and Natural Sciences and Engineering Research Council.

The termination of federal involvement in the Alberta Oil Sands Environmental Research Program and completion of the CANMET - Pit Slope Revegetation Project reduced considerably overall federal research involvement and funding. A decline in funding of the Arctic Land Use Research Program has reduced an already limited support of reclamation research in the north.

Active federal support programs are now confined to the recently announced $9.5 million Uranium Tailings Research Program, including the establishment of a National Tailings Program Office to fund the development of technology to reduce the effects of waste materials from uranium mining and milling. The program includes existing levels of support from AECB, Energy, Mines and Resources and Environment Canada.

The Department of Environment's involvement has been primarily through the Forestry Service, Environmental Protection Service and Parks Service. The Forestry Service and Environmental Protection Service have had a long history of providing advice, reviewing mine proposals or becoming involved in joint research problems with individual mines or regulating agencies. However, there is no overall program or funding support for reclamation research. Parks Canada is primarily involved in the preparation of reclamation guidelines and manuals, as well as field tests to develop suitable plant species for reclamation of disturbances in National Parks. Agriculture Canada's Research Branch has been involved in the reclamation of mine disturbances mostly in agricultural areas on an individual request basis. With the exception of the Uranium Tailings Program, there have been no program initiatives.

PROVINCIAL

The most striking aspect of provincial reclamation programs is that almost 70 percent of the projects have taken place in Alberta. Only one research or operational project was identified for each of Newfoundland and Quebec, and only operational projects were identified for Prince Edward Island. Only a very small percentage (10 percent) of the provincially funded projects were not directly related to reclaiming mine disturbances.

In the Atlantic provinces only 19 projects were identified, 8 initiated by the provinces. At the same time, only two programs were identified in the Atlantic provinces. In 1976, Prince Edward Island initiated a program to reclaim old abandoned pit areas as well as a shared cost program with pit operators. In Nova Scotia, a research and operational program was set up in cooperation with DEVCO (a federal Crown corporation) to cleanup abandoned coal mines and provide a demonstration site for the industry.

In Ontario, the Ministry of Environment has concentrated on metallic and uranium mine waste reclamation and acid drainage problems. The Ministry of Natural Resources has recently terminated a program of funding research on pit and quarry reclamation problems. Within the province, one-third of the projects identified were funded provincially and half federally. New program initiatives for the 1980s include the establishment of a provincial rehabilitation fund to plan for and reclaim abandoned pits and quarries, based on revenues from increased operator's licence fees. Ministry of Environment's Abandoned Mines Program, initiated in 1977, is to continue to develop on a priority basis where the responsible party cannot be identified a strategy and techniques to reclaim abandoned mines that pose immediate or potential hazards.

In the past decade, less than four percent of the projects identified as having provincial involvement occurred in Manitoba and Saskatchewan. Until recently, there has been very little direct involvement in reclamation by either province, particularly at metallic and uranium mine sites. In the past, Saskatchewan's prime focus was on coal reclamation and potash dust fall. In future, the provincial Saskatchewan Power Corporation will conduct most of the coal reclamation research. Saskatchewan has established a new Mine Waste Research Secretariat to coordinate research, while the Mines Pollution Control Branch handles opertional programs. Provincial priorities for new regulations and programs are for coal, uranium, potash, metallic and nonmetallic mines. Funding of revegetation studies at closed uranium mines has already begun, as well as a program to cleanup unsafe abandoned mine sites in northern Saskatchewan. A similar program has been in effect in Manitoba, as well as one to cleanup old pits and quarries.

Alberta has the most comprehensive and extensively funded reclamation program in Canada. In 1977, Alberta established a Reclamation Research Technical Advisory Committee to set up a comprehensive, coordinated reclamation program, in order to eliminate duplication of research and implement research results. To date the operational and research components of the program have spent in excess of $14 million with research funding accounting for $3.5 million ($1.5 million in 1981-82). Currently, there are over 30 reclamation research projects concentrating on problems related to general exploration disturbances, coal mines and oil sands. The province has also undertaken the responsibility of reclaiming all surface disturbances that occurred prior to 1973, except for sites operated by companies in existence after that date.

In British Columbia, a Technical and Research Committee on Reclamation was established in 1976 to influence and coordinate mine reclamation research and to further the communication and development of knowledge. The main coordination of reclamation research is carried out by the Inspection and Engineering Division, Ministry of Energy, Mines and Petroleum Resources. Considerable emphasis is placed on industry conducting its own research. Provincial funding has emphasized metallic tailings research; revegetation of disturbances in the Northeast Coal Block; reclamation of a number of abandoned metal mines, and the publication of research results.

There has been extensive involvement from university researchers in all provinces. University personnel were involved in approximately 111 of 352 projects identified. Ontario and Alberta universities each accounted for approximately 30 percent of the project involvement. The largest single area of research was in "revegetation" studies designed to develop suitable plant species for reclamation (71 percent), followed by metallic mine wastes (31 percent), coal mines (17 percent), and aggregate pits and quarries (10 percent). Only a few universities have maintained an early and continuous involvement in reclamation, namely British Columbia, Alberta, Guelph, Toronto, Waterloo and Laurentian. Added to this group has been an increased involvement at Queen's, Calgary and Saskatchewan. The advantages of direct university involvement has been the increased pool of experienced scientists familiar with the wide range of physical, chemical and hydrological problems associated with mine wastes. Universities are ideally suited to conduct research on problems requiring specialized equipment and knowledge not normally available to mining companies.

In general, after the rapid increase in reclamation research in the mid-1970s, there has been a reduction in the number of government agencies and university personnel. Much of this has been due to improved coordination; the poor state of the economy; and a natural shake-out of less interested or qualified personnel in the reclamation field.

RECLAMATION PROGRESS

Before 1970, approximately two dozen companies had initiated reclamation programs at approximately 30 separate mine sites (excluding construction aggregate sites). The main objectives were to reduce wind and water erosion in an attempt to control contaminated surface runoff, reduce slope failures and improve the general aesthetics of the immediate mine area. By 1980, 50 companies were identified as having established reclamation programs either with their own staff or contracted assistance from private consultants or university scientists at 157 individual mine sites (34 percent were coal mines, and 57 percent metal mines). Despite the increased number of operating companies involved in reclamation, actual progress in terms of reclaimed wastes or disturbed sites has been limited.

In terms of actual progress, only 62 of these sites had a reclaimed area in excess of 2 hectares. The remainder had not yet gone beyond conducting environmental assessments, laboratory analyses, identifying growth limiting factors and/or establishing field trials. By 1980, an estimated 13,753 hectares of the 133,968 hectares of land disturbed by mine wastes had been reclaimed (excluding aggregate sites and abandoned mine sites reclaimed by the provinces). The backlog of land disturbed by coal mines (extraction sites and waste dumps) is estimated at approximately 18,825 hectares, 30 percent of which has been reclaimed. In coal producing provinces requirements that operating companies practice progressive reclamation, coupled with programs to reclaim abandoned sites, should result in time in a decrease in the total area disturbed at any given time.

There was insufficient data available to provide an estimate of the progress in reclaiming abandoned pits and quarries. Even so, it is unlikely that the huge backlog of extraction sites (120,000 hectares) will ever be entirely reclaimed. Better enforcement of existing regulations will be the major catalyst in increasing the amount of land reclaimed.

Due to the vast backlog of unreclaimed sites and particularly in view of current economic circumstances it is unlikely that the overall backlog of land disturbed by mines will be reduced at any significantly increased pace in the near future.

LIMITATIONS TO PROGRESS

The relatively slow progress to date in the amount of land reclaimed can be attributed to one or more of the following factors:

(i) The large amount of land disturbed prior to reclamation requirements being legislated.

(ii) Poor or uneven enforcement of reclamation requirements.

(iii) Difficulty in determining responsibility for reclaiming abandoned mine sites.

(iv) Cleanup and final reclamation of some mine sites has to wait until waste rock, overburden dumps, tailings ponds are no longer operational or until production finally ends. Concurrent reclamation can normally be practiced only at surface coal mines, aggregate pits and exploration sites.

(v) Long term solutions to reclaiming metallic sulphide mine wastes, uranium tailings and oil sands have yet to be found.

(vi) Although many procedures for reclamation were available, they could not be applied until the major inhibiting problem(s) for each site were known. In most cases early attempts initiated test plots on a "hit and miss" basis, rarely did they attempt to incorporate a "Systems Approach" which would have analysed all the potential "on-site" and "off-site" inhibiting factors prior to initiating reclamation activities.

(vii) Until recently the state of knowledge of reclamation techniques rested, to a large extent, with reclamation tests conducted by individual mining companies rather than in long-term knowledge developed through well coordinated research programs. Often there is a question of information credibility, especially research based on inadequately prepared short-term studies.

(viii) There is still very little knowledge of, or research being conducted on, how surface disturbances might affect the movement of water through restored land, both vertically and horizontally into adjoining lands and surface waters. There is a lack of knowledge on the quality of the water, variability of percolation and the effects it may have on watersheds and downstream land and water resources.

(ix) There are still inadequate guidelines defining reclamation requirements.

(x) Until the late 1970s a considerable amount of existing knowledge and new research findings were generally not being made readily available to potential users. A significant number of annual reclamation reports by researchers or operational staff at universities, mining companies or government agencies were not published or made available for distribution. The inability of other researchers to assess and make use of this research limits its value. In many cases, no records were kept at all or if they were, they are very limited and of little value to other users.

RESEARCH PROBLEMS

Asbestos Mines

No large scale land areas have been reclaimed to date. Asbestos tailings are alkaline, high in nickel and chromium, low in available macro-nutrients and organic matter. They also suffer from droughtiness, poor structure and cemented surface crusts. Research so far has determined that organic matter amendments are absolutely necessary. Sewage sludges proved successful in establishing grasses and legumes, but in terms of large scale reclamation it proved too costly to transport. Steep waste dump angles of 30° to 40°, made it difficult to incorporate amendments. Alternate testing of species accustomed to droughty alkaline conditions are currently being evaluated.

Potash Mines

It is not possible to reclaim the 3,000 hectares of salt waste dumps and brine ponds until mining operations are terminated. No revegetation research has been attempted, however, research has determined that soil contaminated by the potassium in mine dust can be ameliorated by adding up to 22 tonnes per hectare of dolomite.

Aggregate Pits and Quarries

The experience, technology and planning procedures needed to rehabilitate aggregate pits and quarries are already available and proven. One of the biggest problems in attempting to reclaim pits and quarries, however, is the fact that topsoil and subsoil from the site were rarely stockpiled, most of it being sold. This precludes restoring the site to agricultural production. Another problem on older sites is the extraction has reached levels below water tables or to impermeable layers. In terms of research, very little attention has been paid to subsurface movement of water in reclaimed sites and readjustment of water tables.

Uranium Mines

Extensive research into reclaiming uranium mine tailings has been going on for over a decade at Elliot Lake, Ontario and more recently at Uranium City, Saskatchewan. Stabilization of uranium tailings by revegetation is possible, although it has yet to be determined whether or not it is self-sustaining. Acidification has continued despite revegetation; and recommended rates of limestone have had no effect on the leaching rate of various radionuclides. Recent research appears to have shown that the method of reclaiming uranium tailings using limestone, grass cover and refertilization is an ineffective means of preventing acidification and infiltration. The long-term potential hazard to the environment continues, since the amount of tailings acidified increases each year, thus increasing the amount of acidic seepage containing radionuclides and heavy metals. Future research must concentrate on controlling hydrological conditions in the tailings or alternately finding within-mill treatment or some safe burial method.

Metallic Mines

Between 1970 and 1980 the amount of metallic mine wastes reclaimed increased from 637 to 5,480 hectares, or slightly less than 10 percent of the total metallic mine wastes. Generally, metallic mining wastes that do not contain iron sulphide minerals that can be reclaimed. The most important problems still preventing successful reclamation of metallic mine wastes involve the presence of sulphur and sulphur compounds and/or arsenic and arsenic compounds. Over two decades of research on acid sulphide tailings has still not provided an adequate understanding of the factors affecting plant growth in chemical or biological terms, especially hydrological conditions in the tailings and the relationship between waste particles and pore water. As in the case of uranium tailings, heavy liming does not necessarily prevent acidification, nor does capping wastes with overburden constitute a permanent solution to highly acid mine wastes, particularly tailings. Applications of overburden have been partially successful at depths greater than 60 centimetres, but it is a technique of last resort because of the high cost and poor availability of sources of innocuous materials.

Applied research and operational reclamation programs at metallic mine sites are still heavily weighted toward the direct seeding approach with amendments of agricultural limestone and fertilizer. Using agronomic plant species is still the predominant choice for establishing a vegetative cover. The approach helps to stabilize slopes, control surface erosion, and build up the organic matter content and structure of the mine wastes.

More attention is now being paid to procedures which combine the use of native species with assisted or successional planting. Sites are initially stabilized with rapidly growing cover species (agronomic) and then artificially prepared for native species recolonization. Low sulphide tailings and wastes dumps have been reclaimed using this approach. However, the question of how long maintenance fertilizer is required still remains.

Birdsfoot trefoil has become the most reliable species in all successful reclamation programs for acidic, neutral and slightly alkaline mine tailings. It appears to adapt to a wide variety of moisture conditions and is winter hardy.

North of 60°

There is still very little reclamation research being conducted in the north. The physical and chemical problems encountered are similar to those identified for metallic mines above, but added to this are the greater climatic limitations of botanical choices and the slower growth rates. The future thrust of reclamation research in the north is likely to continue along the lines of obtaining native species which are tolerant to acid (or alkaline) and elevated heavy metal conditions, as well as the harsh climatic conditions. For general surface disturbances or mine wastes without an acid or heavy metal content problem, research being conducted on native grasses and shrubs in the alpine and subalpine areas of Alberta, British Columbia and Alaska should be considered for use in the north.

Oil Sands

After a decade or more of research, the industry still does not have the technology to reclaim oil sands. Research is continuing on soil reconstruction and the selection and propagation of suitable trees and shrubs. The Alberta Government and the oil sands industry have developed a comprehensively funded program to identify a satisfactory reclamation procedure.

Coal Mines

Enough experience, technology and planning procedures have been developed to make considerable progress in reclaiming coal mine disturbances, albeit to varying degrees of success. Concurrent reclamation and field research is now being conducted at all surface coal mines in Canada. At this time, coal mine disturbances are being reclaimed at a greater rate than any other sector of the mining industry. This is partly due to the fact that growth factors at surface coal mines are not as severely limiting as those at base metal, uranium or asbestos mines. In addition the mining methods are conducive to concurrent reclamation, and, in agricultural plains, there is more topsoil and subsoil available to be selectively stripped. But there are still a number of outstanding problems affecting the successful reclamation of individual sites that have to be overcome.

In the Agricultural Plains of Alberta and Saskatchewan, coal seams overlain by bedrock containing a high proportion of swelling clays run into problems when the clay is exposed to the elements. The clay becomes sticky and unmanageable when wet, and cement-like when dry. Many areas have highly saline soils and overburden materials that inhibit plant growth unless properly burned. The optimum depth of topsoil necessary for selective replacement in soil reconstruction still has not been determined. A major problem in the plains is the fact that the coal seams are major sources of groundwater and it is uncertain what effect the removal or disturbance of the coal and overburden will have on future supplies. There are still unanswered questions with regard to hydrological properties, infiltration patterns and water table readjustment in reconstructed soils. It is also not certain what will be the long-term viability of lands reclaimed to agricultural uses. This may take five to ten years to determine.

In the Atlantic provinces the waste rock overburden has a two to eight percent sulphur content which has acid drainage producing potential. Therefore, careful burial of these wastes must take place.

In the Cordillera, reclamation on the smoother slopes and lower elevations of the foothills has been more successful, but in the mountains steep erodable slopes, unstable rocky spoils, droughtiness, short growing season and lack of soils and nutrients all contribute to slower progress. The very thin mountain soils make selective materials handling and storage of toposil difficult or impossible in places. Thus solutions have to be found on how to reconstruct a soil-plant system without indefinite maintenance requirements. In order to find solutions to these problems, research is being directed towards the development of native plant species for high elevations; reconstruction of native soils if available or development of a viable soil growth medium on overburden waste dumps; development of initial cover crops to stabilize exposed slopes for erosion control and enhancement of successional revegetation.

RECLAMATION COSTS

There is still very little data on the costs of reclamation in the various sectors of the mining industry. If, as is often contended, reclamtion requirements add directly to the cost of mining, then a better understanding of the role that reclamation costs play in the total mining operation is important to future mine devlopment. Reclamation requirements are no longer confined to a post-mining operation; they are an integral element of all stages of mining today. Regulations and reclamation standards apply to exploration as well as to the development and post-mining cleanup stages of a mine's existence. More accurate, itemized records on the various costs will provide an effective method of comparing different reclamation techniques, providing operators and regulating agencies with overall cost indicators. Reliable information that describes project actions and related costs is needed to permit regulating agencies to assess the impact of regulatory requirements.

Increased requirements for reclamation coupled with the rising influence of resource management policies has also led to a dramatic increase in the involvement of various government agencies. These demands have added a new dimension to the overall public cost. It has led to increased government support in the form of research funds, subsidies, specialized advice, inspection, in addition to the more specific information and data collection by traditional government service agencies — geological, soil, hydrological and forest inventories. At all levels of government, with a few exceptions, the funding and manpower necessary to conduct these support activities for new legislative initiatives have often been sporadic or far too low to meet long-term goals.

Better records are needed to understand the impact of regulations on overall costs of operating a mine. It is important to determine what resources are required to meet various reclamation objectives and policies. Accurate cost information is needed to differentiate between which methods are technically and economically feasible now or in the near future. In some provinces, progress in inspection, monitoring and the use of annual reports has contributed considerably to this end, but it is not a uniformly adopted procedure.

There is no generally accepted list of reclamation costs or natural grouping of costs applicable to all mining conditions. The range of factors involved in determining the reclamation costs of a given project will vary considerably according to the degree of reclamation required, size, type and location of mine activities. Fifteen cost centres have been identified for the purposes of illustrating the wide range of factors influencing reclamation costs. They represent five broad categories of costs:

(i) Planning and design, including baseline data collection, field surveys, environmental and socio-economic impact assessments, planning mine development, research and field testing;

(ii) Bonds and security deposits;

(iii) Materials handling and ground preparation; including selective materials handling, material capping, ground preparation, drainage and sediment control;

(iv) Revegetation; including additional surface treatment (stabilizers), soil amendments, and actual process of revegetation, and

(v) Follow-up maintenance and monitoring.

Not all of these factors will be applicable to every mine site. However, records taking into account these items will advance the overall understanding of the costs of reclamation.

RECOMMENDATIONS

From this review of reclamation research and applied operations, it is evident that there are considerable gaps in knowledge of and capability to reclaim various mine disturbances and waste by-products. To assist in closing these gaps, a number of recommendations are presented.

There is a need for an overall national reclamation and research development program to be established which concentrates on the following priority areas:

(i) ***Metallic sulphide ores***: No satisfactory mine close-out method has been identified to control the acid seepage problem and associated leaching out of heavy metals from mine wastes into the surrounding environment. There is a need to develop a better understanding of the interrelationships between the physical, chemical and biological processes that take place in mine wastes, especially hydrological conditions and relationships between waste particles and pore water. There is also a need to determine whether or not essentially complete dependence upon reclamation by revegetation is a viable close-out option.

(ii) ***Hydrological Aspects of Mine Waste Reclamation***: An increased program of research is needed to address unanswered questions with regard to surface and subsurface hydrological properties, infiltration patterns, water table readjustments in unaltered mine wastes, reconstructed soils, and amended mine wastes. There is a need to be able to predict long-term behaviour and dispersion patterns of contaminants within and beyond unaltered and reclaimed mine wastes. The program needs to focus on wastes from metallic and uranium mines and coal surface-mines in the Western foothills and prairies, and Atlantic provinces.

(iii) ***Coordination and Exchange of Reclamation Information***: There is a need to establish a centralized information database that is national in scope to facilitate the exchange of information on reclamation. Research findings should be reported and collected on a standardized form acceptable to the major shareholders involved - provincial agencies, mine operators, interested consultants and university researchers. Increased efforts are needed to make available unpublished reports from all sources - government, industry and universities - and to coordinate and synthesize the results of laboratory and field measurements already made in reclamation programs. The establishment of a centrally coordinated database will enable major interested parties to know what research is going on at any one time so as to ensure that duplication of effort is minimized.

(iv) ***Mine Waste Research North of 60°***: A program of research is required to obtain more precise data and criteria to assist in decisions on whether or not reclamation is a viable option in closing out mines in the north; to determine whether or not there are viable alternatives to assisted/successional revegetation on northern mine wastes and disturbances; and identify what plant species have already or are capable of adapting to adverse physical and chemical conditions of mine wastes and the harsh climate of the north. There is a need to develop specialized techniques capable of reclaiming placer mining disturbances.

In order to develop a program to meet the needs of these priority areas, the following objectives should be considered:

a) Investigation of alternative mine waste disposal techniques including: shallow burial, deep burial, deep lake chemical stabilization, and removal of contaminants within the milling process, in order to eliminate the need for reclamation or reduce the number of inhibiting factors to successful reclamation.

b) Support for the development of specialized equipment types suitable for revegetation and reclamation purposes at Canadian mine sites.

c) Development of uniform standards for field measurements and analytical laboratory tests which are related to the nature of the wastes rather than to soils acceptable to all principal shareholders in reclamation.

d) Support of experimental research and field testing to evaluate and recommend propogation methods for native plant species capable of use in reclaiming mine wastes in various ecotypes throughout Canada; ultimately to provide for a centralized database of plant species suitable for reclamation at various types of mine disturbances across Canada; and to support establishment of cooperative centres to provide adequate seed and planting stock.

e) Implementation of abandoned mine site investigations to conduct and monitor field tests directed at characterizing mine wastes, soil-water adjustments by recolonization of native plant species and identification of species that have developed tolerances to adverse mine waste conditions.

f) Establishment of a number of fully instrumented test sites in various ecological settings to evaluate long-term hydrological characteristics of mine wastes including vertical and horizontal movement of water, quality of water, variability of percolation, water table readjustments, and soil-pore water relationsnips in unaltered and amended mine wastes and reconstructed soils on former mine disturbances.

g) Establishment and operation of a centrally coordinated on-line computer assisted information retrieval system for access to all forms of mine reclamation related information, including funding support and principal researchers in various disciplines to collect and collate data according to ecological zones, type of mine disturbances, growth limiting factors, current status of reclamation techniques, and current use of various plant species. The establishment of such a centralized system would build on existing coordinating and data collection systems established by the two senior levels of government by complementing or supporting expansion to cover gaps in existing information and exchange mechanisms.

h) Maintain a national inventory of operating and reclaimed mine sites, updated annually to reflect the relationship between disturbed and reclaimed areas.

The recently announced National Uranium Tailings Research Program by the Canada Centre for Mineral and Energy Technology (CANMET) may provide the best model for implementing many of the above recommendations. The establishment of a National Tailings Program Office to manage the research and development program on uranium tailings could be expanded to include many of the priority research areas outlined above. CANMET may be the most ideally suited centre to coordinate the collection and exchange of reclamation information in cooperation with provincial agencies, mine operators and the various mining associations. All aspects of the data collection program need not be centrally located, as regionalized centres of expertise could be established, or built on existing provincial ones, with inter-connecting on-line computerized capabilities (e.g. coal and oil sands in Alberta; arctic and alpine in British Columbia; asbestos in Quebec, etc.).

In most cases the decisions to proceed with reclamation or management of disturbed lands are in response to public opinion. It has taken over a decade for industry, or for that matter both senior levels of government, to accept reclamation as a factor in the overall assessment of resource development costs.

The question is not one of ability to pay, but rather one of priorities and willingness to redirect economic resources from other uses to land reclamation. The extent to which the developer is expected to protect the environment is essentially a function of economic priorities as determined by society. In many ways current legislation and its enforcement reflect society's priorities. We have accepted a Canada-wide goal to eliminate health hazards, but regional and provincial economics have dictated the level of environmental quality we are prepared to pay for in terms of money, standards of living and freedom of choice.

Much of the reclamation regulations define successful reclamation with the term, "self-sustaining, productive plant cover". The self-sustaining state is the goal most actively sought, representing the point at which the mine operator can recover his security deposit and relinquish responsibility for the land. Should the land prove incapable of sustaining an adequate cover, then the owner is responsible for mitigating any resultatnt adverse environmental impacts. Therefore, it is critical that senior levels of government and mine operators acquire techniques which provide for the best possible evaluation of whether or not an area can be reclaimed. The federal and provincial governments must determine whether or not the potential benefits of reclamation are worth the cost, particularly where there are considerable practical difficulties because of limiting physical, chemical, locational and climatic conditions. Canada's resource development takes place in such a wide variety of locations that it is most logical to consider the environmental problems on an individual or regional basis rather than by attempting to impose uniform requirements. A greater expansion of coordination and cooperation between the various levels of government and industry will be necessary in order to ensure a continued growth in resource development and commitment to adequate protection of the land resource base. With respect to reclamation, ideal objectives are easily stated, but knowledge is often limited, both as to the effects of land degradation and the most suitable means of reclaiming the disturbed lands. In some cases, it may not be technically possible or economically feasible to consider reclamation, and society should be prepard to accept this.

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APPENDIX 1. LEGISLATION CONCERNED WITH ENVIRONMENTAL CONTROL IN THE MINING INDUSTRY

The Acts and Regulations identified below may be used under certain circumstances to enforce some aspects of land reclamation or curtail continued land degradation practices.

Planning and Municipal Acts which provide for zoning and/or development controls that may restrict mining activities due to environmental factors have been included. Most have a more direct influence on the aggregate industry.

LEGISLATIVE ACT	**RELEVANCE TO MINING AND ENVIRONMENT Regulations, Guidelines, Objectives and Codes Issued**
FEDERAL	
Arctic Waters Pollution Prevention Act. (R.S.C. 1970, c.2)	Regulates the disposal of waste material into Arctic waters which might damage or change the natural ecological balance of the water, or its associated plant, animal or fish life. • Arctic Waters Pollution Prevention Regulations
Clean Air Act (S.C. 1970-71-72 c.47)	The Act is Canada's major legislation with respect to air pollution and the establishment of air quality objectives. National ambient air quality objectives have set limits on levels of pollutants in the air. • Ambient Air Quality Objectives • Arctic Mining Industry Emission Guidelines • Asbestos Mining and Milling National Emission Standard Regulations • Metallurgical Industries Arsenic Information Regulations • Metallurgical Industries Mercury Information Regulations • Metallurgical Coke Manufacturing Industry Emission Guidelines
Canada Water Act (R.S.C. 1970, (1st Supp.) c.5)	The Act provides for the management of water resources and water quality.
Criminal Code (R.S.C. 1970 c.34, as amended 1972, c.13)	Any person who pollutes water, land and air with anything that endangers lives, safety, health or comfort of the public is guilty of an indictable offence and liable to imprisonment or fine.

LEGISLATIVE ACT	RELEVANCE TO MINING AND ENVIRONMENT Regulations, Guidelines, Objectives and Codes Issued
Fisheries Act (R.S.C. 1970 C.F-10 as amended to 1977)	The Act provides for the establishment of regulations to protect fish and other aquatic life from the discharge of deleterious substances from base metal, uranium and iron ore mines. Requires plans and specifications for any construction or work likely to result in deposition of deleterious substances in water or in a place where it is likely to end up in water. • Guidelines for the Control of Liquid Effluents from Existing Mines, 1977 • Guidelines for the Measurement of Acute Toxicity and the Control of Effluents from New, Expanded and Reopened Metal Mines.
Environmental Protection Ordinance (R.O., N.W.T., 1974, E-3)	Prohibits discharge into environment of a contaminant that causes impairment of environmental quality or afffects health, safety or comfort of any person.
Migratory Birds Convention Act (R.S.C., 1970, M-12 as amended)	Act to protect all migratory birds within all territories and provinces of Canada. No person shall deposit or permit the deposit of substances harmful to migratory birds in any waters or any area frequented by migratory birds. Does not apply to deposition when authorized by regulations under another Act.
Northern Inland Waters Act (R.S.C. 1970, c.28, as amended to 1975)	Management of waters not covered by Canada Water Act. Covers control of diversion and obstruction of watercourses and deposition of wastes in water.

LEGISLATIVE ACT	**RELEVANCE TO MINING AND ENVIRONMENT Regulations, Guidelines, Objectives and Codes Issued**
NEWFOUNDLAND	
Department of Consumer Affairs and *Environment Act* (S. Nfld. 1973, c-39; as amended 1974, c-4; 1975, c-58)	Provides for the protection and enhancement of the natural environment including the quality of water, air and soil. It provides for the proper utilization of water resources through conservation, development, control and improvement. • Environmental Control Regulations (N. Reg. 32/74)
Waste Material (Disposal) Act (S. Nfld. 1970, c.394; as amended 1976, c.63)	A licence for waste disposal sites must be obtained whether on private property or Crown land.
Waters Protection Act (R. Nfld. 1970, c.394; as amended 1973, C.48 S.16)	Contains regulations to prevent water pollution or to remendy any situations where pollution is already found in waters.
Ore Treatment Tailings (Labrador) Disposal Act (R. Nfld. 1965)	Restricts the rights of owners, occupiers and users of land adjacent to lands or water affected by ore treatment tailings from iron mines. Within a specified geographical area, the Act stops such individuals from obtaining injunctions which would halt the disposal of tailings from iron mining operations.
Wildlife Act (R. Nfld. 1970, c.400)	Provides for the management and control of all measures of any kind for the protection and preservation of wildlife. Obstruction and pollution of non-tidal waters frequented by fish is not permitted.
Department of Forestry and Agriculture Act (S. Nfld. 1973, c.37)	Directs all matters relating to forest resources and the utilization, protection, conservation, management, and development of the forest resources.
Urban and Rural Planning Act (S. Nfld., 1970)	Provides for municipalities to be involved in regional land use planning and resource exploitation.
Crown Lands Act (S. Nfld. 1970, c.71; 1973, c.37; 1974, c.85; 1975, c.36)	Provides for the sale or lease of Crown lands for residence, agriculture and industry; water powers, and timber lands.

LEGISLATIVE ACT	**RELEVANCE TO MINING AND ENVIRONMENT Regulations, Guidelines, Objectives and Codes Issued**
NOVA SCOTIA	
Water Act (R.S.N.S. 1967, c.385 as amended 1972, c.58)	Responsible for approving all water rights applications. Prohibits the discharge of any pollutant into a watercourse. Any facility requiring a water flow diversion or alteration must obtain approval of plans. • Water Regulations
Lands and Forests Act (R.S.N.S. 1967, c.163)	Responsible for the granting, leasing and licensing of Crown Land.
Forest Improvement Act (R.S.N.S. 1967, c.114	Sets out the province's policy on protection and rejuvenation of forests. Prohibits tree cutting within 100 feet of riverbanks.
Public Health Act (R.S.N.S. 1967, c.247; as amended 1968, c.50; 1969, c.69; 1970, c.62; 1973, c.50)	Responsible for preventing contamination of air, water or soil by any substance that may endanger public health or may become a nuisance.
Planning Act (S.N.S. 1969, c.16)	Allows the minister of Municipal Affairs to regulate subdivision development to ensure that urban development does not deleteriously impact upon water quality. Provisions for communities to take part in land use planning.
Town Act (R.S.N.S. 1967, c.309)	Gives the authority to towns to make bylaws with regard to regulating and controlling the emission or discharge of smoke, odors and gases, and to prescribe standards regulating such emission and discharge.
Municipal Act (R.S.N.S. 1967)	Gives the authority to municipalities to make by-laws with regard to regulating and controlling land use within their jurisdiction.
PRINCE EDWARD ISLAND	
Fish and Game Protection Act (S.P.E.I. 1974, C. F-8)	Responsible for regulation and management of fish and game including wildlife. Provides for the protection of watercourses frequented by salmon from any contaminant including lime.
Recreation Development Act (R.S.P.E.I. 1969)	Provides for the designation of any area as a public park, protected area or beach, including land under tidal water. Controls extraction of sand.
Unsightly Property Act (R.S.P.E.I. 1974, C. F-8)	Requirements for the proper disposal and sanitary condition of a property.

LEGISLATIVE ACT	**RELEVANCE TO MINING AND ENVIRONMENT** **Regulations, Guidelines, Objectives and Codes Issued**
NEW BRUNSWICK	
Clean Environment Act (R.S..N.B. 1973, c. C-6; as amended 1974, c.4; 1975, c.12)	Prohibits deposition into water, air or soil any contaminant or waste by any person either directly or indirectly. Any facility that may contaminate the environment is regulated by the Minister of the Environment. • Air Quality Regulations • Water Quality Regulations • Watercourse Alteration Regulation • Environmental Impact Assessment Guideline
Ecological Reserves Act (R.S.N.B. 1973, C.E-11)	Sets out two types of reserves: wholly protected and managed. A managed area is open to some activity. In a wholly protected area there is to be absolutely no intrusion.
Community Planning Act (R.S.N.B. 1972)	Administered by the Department of Municipal Affairs has provision for the control and abatement of pollution, allows communities to have a say in the development of the area.
Municipalities Act (R.S.N.B. 1972)	Administered by the Department of Municipal Affairs, has provisions allowing municipalities to regulate the operation and maintenance of abandoned gravel pits and allow municipalities to prescribe fines for violations.
QUEBEC	
Environmental Quality Act (S.Q. 1974, c.29; as amended 1974, c.51; 1977, c.55; 1978, c.64; 1978, c.94)	Responsibility for air, water and soil pollution control and solid waste disposal. Prohibits emission, depsotion and discharge to atmosphere, soil or water of any contaminant of concentrations greater than guidelines. • Liquid Waste Management Regulation • Pits and Quarries Regulation • Solid Waste Management Regulation
Ecological Reserves Act (S.Q. 1974, c.29; as amended 1979, c.49)	Reserves can be established to preserve the natural state or for scientific research or to safeguard animal and plant species threatened with disappearance or extinction. Mining operations, exploration or prospecting are forbidden.
James Bay Region Development Protection Act (S.Q. 1971, c-34)	Regulates the pollution control and protection of the environment in the James Bay region.
Agriculture Land Preserve Act (S.Q. 1978, c.10)	Protects agricultural land from being converted to other uses.

LEGISLATIVE ACT	**RELEVANCE TO MINING AND ENVIRONMENT** **Regulations, Guidelines, Objectives and Codes Issued**
Quebec Urban Community Act (S.Q. 1969, c.83, c.84, c.85)	Provisions for the regulation of land use and development plans.
Public Health Protection Act (S.Q. 1972, c.42)	Prohibits any threat to human health by pollutants or public nuisances. Prohibit the discharge of heavy metals into the environment.
ONTARIO	
Environmental Protection Act (S.Q. 1971, c.86, as amended 1972, C1, s.69; 1972, c.106; 1973, c.94; 1974, c.125; 1976, c.49; 1979, c.91)	Prohibits the discharge and dumping of any contaminant into the natural environment in amounts, concentrative or levels exceeding those prescribed by regulations. Air pollution regulations and waste management regulations cover rock fill or mill tailings, disposal systems and sites. Effluent guidelines and receiving water quality objectives for the mining industry are included. • Air Pollution Control (General) Regulations • Ambient Air Quality Criteria Regulation • Environmental Protection (General) Regulations
Ontario Water Resources Act (R.S.O. 1970, c.332; as amended 1972, c.1, s.70; 1973, c.90; 1974, c.19; 1975, c.71)	Act gives the Ministry of Environment extensive powers to regulate water supply, sewage disposal and the control of water pollution. To supervise and examine all surface and ground waters, and to determine the extent, nature and causes of contamination in those waters. Can control water resource interference from pit and quarry operators by use of water taking permits; a certificate of approval, or licenses to operate. • Water Management — Goals, Objectives, Policies and Implementation Procedures. • Objectives for the Control of Industrial Waste Discharges in Ontario
Conservation Authorities Act (R.S.O. 1970, c.78; as amended 1971, Vol. 2 c.64, 1972; c.1, s.84; 1973, c.98)	Establishes conservation authorities to further the conservation, restoration, development and management of renewable natural resources, Prohibits the placement or discharge of any solid fill that may cause flooding or pollution.
Beaches Protection Act (R.S.O. 1970, c-40)	Prohibits removal of sand from beds, banks, beaches, shores or waters of any Ontario river, lake or stream except where a license has been issued.

LEGISLATIVE ACT	RELEVANCE TO MINING AND ENVIRONMENT Regulations, Guidelines, Objectives and Codes Issued
Endangered Species Act (S.O. 1971, Vol. 2, c.52)	Provides for the conservation, protection, restoration and propagation of flora and fauna threatened with extinction.
Planning Act (R.S.O. 1980, c.379)	Gives the authority to Regional Municipalities to control land use planning and development within their jurisdiction.
Municipal Act (R.S.O. 1980, c.302)	Gives the authority to municipalities to make by-laws with regard to regulating and controlling land use within their jurisdiction.
MANITOBA	
Clean Environment Act (S.M. 1972, c.76; as amended 1974, c.41; 1975, c.42; 1976, c.37; 1977, c.57; 1978, c.17)	States that no person either directly or indirectly, shall cause, suffer or permit the contamination of the environment in excess of prescribed limits. Controls waste material disposal, air, water and noise pollution. • Guidelines for Various Air Pollutants • Provincial Objectives of Surface Water Quality • Waste Disposal Grounds Regulation
Public Health Act (R.S.M. 1970, c.M225)	Concerned with public health, but applies to open pit mine operations with regard to water supply, and sewage disposal.
Water Rights Act (R.S.M. 1972)	Act controls the use and management of surface ground water. Requires a license for any use, diversion, damming, impounding, etc.
Groundwater and Well Water Act (R.S.M. 1969)	Act requires precautions to ensure that no substance pollutes, contaminates or diminishes ground water purity.
Planning Act (S.M. 1975, c.29)	Provides for land use planning, development and zoning restrictions within the province. • Land Use Policy — Manitoba Regulations
SASKATCHEWAN	
Air Pollution Control Act (R.S.S. 1965, c.267, amended 1973, c.3)	Prohibits emission into the atmosphere of any contaminant that may affect the quality of the atmosphere. Regulations require mine operators to undertake waste control programs to prevent the pollution of air, and indirectly to protect water or soil from pollution caused by the airborne transport of contaminants. • Air Pollution Control Regulations.

LEGISLATIVE ACT	**RELEVANCE TO MINING AND ENVIRONMENT Regulations, Guidelines, Objectives and Codes Issued**
Groundwater Conservation Act(R.S.S. 1965, c.362)	Provides for regulations for the conservation and use of groundwater. Regulations require any person utilizing groundwater for an industrial source or changing the groundwater pattern to submit detailed specifications for a licence.
Water Resources Management Act (R.S.S. 1972, c.146, amended 1976-77, c.101)	The Act provides the management of water resources in Saskatchewan. No person shall discharge, deposit, drain or release any substance capable of changing the quality of water or causing water pollution. • Water Pollution Control Regulations
Ecological Reserves Act (R.S.S. 1979-80	The Act provides for the designation of any Crown land as an ecological reserve. Sets conditions under which it may be entered and activities that may be conducted in the reserve.
Urban Municipality Act (R.S.S. 1978, U-10)	Gives the authority to urban municipalities to make by-laws with regard to regulating and controlling land use within their jurisdiction.
Rural Municipality Act (R.S.S. 1978, R-26)	Gives the authority to rural municipalities to make by-laws with regard to regulations and controlling land use within their jurisdiction.
Planning and Development Act (R.S.S. 1978, P-13)	Provides for land use planning and development within the province.
ALBERTA	
Clean Air Act (S.A. 1971, c-16)	Establishes and regulates the maximum air pollution allowable in the atmosphere. No mining construction may proceed without approval of plans and specifications. • Clean Air Regulations • Clean Air (General) Regulations • Clean Air (Maximum Levels) Regulations
Clean Water Act (S.A. 1971, c.17, amended 1972, c.20; 1974, c.17; 1976, c.65)	Provides controls for effluent quality. Prohibits dumping of any deleterious substances that may impair water quality. Requires a permit to construct and a licence to operate any structure that may influence water bodies. • Clean Water (Authority Designation) Regulations • Clean Water (General) Regulations • Clean Water (Industrial Plants) Regulations.

LEGISLATIVE ACT	**RELEVANCE TO MINING AND ENVIRONMENT Regulations, Guidelines, Objectives and Codes Issued**
Department of Environment Act (S.A. 1971, c.24, as amended to 1977)	Provides for conservation, management and utilization of natural resources; prevention of pollution.
Environment Conservation Act (R.S.A. 1970, c.125, amended 1971)	Established an Environmental Conservation Authority to conduct a continuing review of policies and programs of the government of Alberta pertaining to environment conservation and report and make recommendations to the Minister and/or Lieutenant Governor in Council, and hold public hearings to ensure public participation in major environmental questions and in major new projects.
Environment Council Act (R.S.A. 1970, c.125, as amended to 1977)	Provides for the continuation of the Environmental Conservation Authority as a corporation called the Environment Council of Alberta. Under this Act the Council requires direction to proceed with a specific inquiry.
Energy Resources Conservation Act (S.A. 1971, c.30, as amended to 1976)	Establishes the Energy Resources Conservation Board, which administers several Acts which have pollution control provisions, including the Coal Conservation Act.
Coal Conservation Act (S.A. 1973 c.65 as amended to 1975)	The evaluation of coal deposits and their economic development is the prime concern of the Act. • Coal Conservation Regulations • Coal Development Policy for Alberta
Public Lands Act (S.A. 1970, c.297, amended 1975 (2) C-10)	Regulates the administration of land held in the name of the province. Provides for the removal of facilities after abandonment of mining on public land. Ensures rehabilitation.
Forest Reserves Act (R.S.A. 1970, c.146)	Ensures that certain forest areas are conserved for forest growth as well as other revegetation.
Wildlife Act (R.S.A. 1979, c.391)	Sets out the policy for sanctuaries and other protected areas for birds and other wildlife.
Planning Act (R.S.A. 1980, c.p.9)	Provides for land use planning, and development within the province.

LEGISLATIVE ACT	RELEVANCE TO MINING AND ENVIRONMENT Regulations, Guidelines, Objectives and Codes Issued
BRITISH COLUMBIA	
Environment and Land Use Act(S.B.C. 1971, c.17; amended 1977, c.75)	Ensures that all aspects of preservation and maintenance of the natural environment are fully considered in administration of land use and resource development commensurate with the most beneficial land use and minimum of adverse after-effects. Council of six ministers and orders from this Act override all existing provincial legislation.
Agricultural Land Commission Act (S.B.C. 1977, c.73)	Responsible for the preservation of designated agricultural lands.
Pollution Control Act (S.B.C. 1967, c.64, as amended to 1977)	Established the Pollution Control Board to develop pollution control objectives for selected industries. Hears appeals against decisions of the Director of Pollution Control who issues or refuses permits for discharges to the air, water or land; and has discretionary powers to hold public hearings.
Soil Conservation Act (S.B.C. c.8)	Provides that the Agricultural Land Commission give permission to remove or place topsoil on agricultural reserve lands.
Health Act (R.S.B.C. 1960, c.170 as amended to 1975)	Prohibits endangering life or safety of public by deposition or emission of any contaminant into the environment.
Water Act (R.S.B.C. 1960, c.405)	Sets out the administration of all surface fresh water, provides the water licences and approvals, and for water use in communities.
Ecological Reserves Act (S.B.C. 1971, c.16)	Provides for the establishment and administration of Crown lands reserved for ecological purposes.
Municipal Act (R.S.B.C. 1979, c.290)	Gives authority to municipalities to make by-laws with regard to regulating and controlling land use within their jurisdiction.

APPENDIX 2. FEDERAL ENVIRONMENTAL CODE OF PRACTICE FOR MINING: REHABILITATION GUIDELINES

5.1 General

5.1.1. The objective of rehabilitation measures should be to chemically and physically stabilize the area once active production has terminated so that any drainage streams from the inactive site meet the acceptable levels given in Table 1 and the area, depending on its potential uses, is generally acceptable from the standpoints of aesthetics and safety.

5.1.2 When determining the location, height, grading and side slopes of waste rock piles, consideration should be given to possible rehabilitation measures.

5.1.3 Mine operators should develop and cost a planned approach to rehabilitation of the mining site based on the anticipated life of the mine at the time of development. Rehabilitation should be started as soon in the life of the operation as possible.

5.1.4 The cost of rehabilitation should be borne by the mine operator and, therefore, internalized as part of the cost of production.

5.2 Long-Term Control of Contaminated Effluents

5.2.1 Requirements for controlling contaminated effluents after active operation are the same as those applicable to the active phase. Means should, therefore, be found to seal or eliminate sources of contaminated drainage in order to avoid the need to collect and treat such drainage, possibly in perpetuity. Consideration should be given to the following aspects:

- mine workings;
- tailings disposal areas;
- waste rock and lean ore dumps;
- general working areas, concentrate handling, etc.; and,
  - exposed sulphidic rock surfaces (highway cuts, etc.).

5.2.2 Where it is not possible to stabilize the area, provision should be made to treat the contaminated drainage for as long as such contamination occurs.

5.3 Rehabilitation of Open Pits and Mine Workings

5.3.1 Contaminated water accumulating in open pits or other mine workings should be hydrologically isolated or treated.

5.4 Rehabilitation of Tailing Areas

5.4.1 Steps should be taken to control contaminated seepage and runoff from tailings inpoundment areas and to physically and chemically stabilize the surface of these areas.

5.4.2 Tailings impoundment areas should be located, designed and operated with a view to facilitating their ultimate or staged rehabilitation. Consideration should be given to measures such as:

- isolation of chemically reactive wastes;
- design of drainage characteristics of the retaining structures to create either a free draining mass or to minimize seepage, depending on the quality of the seepage anticipated;
- suitable means for collecting contaminated seepage;
- methods of surface stabilization envisaged, such as chemical, physical or vegetative; and,
- long-term diversion of uncontaminated surface drainage contributing to the area as specified in Section 2.4.3; and,
- alternative methods of disposal or uses of tailings.

5.4.3 Consideration should be given to stripping and storing topsoil or other materials which might be used at the rehabilitation stage if these would otherwise be made inaccessible by the development.

Source: Fisheries and Environment Canada, 1977. pp. 20-22.

APPENDIX 3. PROPOSED NOVA SCOTIA PIT AND QUARRY REGULATIONS: REHABILITATION REQUIREMENTS

II. Rehabilitation:

1 Every operator of a permanent pit or quarry shall while the pit or quarry is in operation, progressively rehabilitate the pit or quarry to the final grade and contours indicated on the site plan.

2 Where pits and quarries are to be operated on a seasonal or intermittent basis the site shall be rehabilitated prior to each temporary abandonment.

3 Except in the case of a pit or quarry when the final slopes shall be those slopes indicated on an approved site plan, every final excavation face of a pit or quarry shall not exceed a slope of one to one (1:1) (horizontal:vertical).

4 Every pit excavation made to a water producing depth shall have all banks sloped to the water line at a slope which shall not exceed one and one-half to one (1½:1) (horizontal:vertical).

5 (a) Every operator of a pit or quarry shall stockpile existing topsoil, stripping, fill or waste rock to facilitate rehabilitation of the pit or quarry.

(b) Every stockpile referred to in subsection (a) shall have stable slopes so as to prevent erosion.

6 Existing topsoil in sufficient quantity and depth to raise and maintain a healthy growth of vegetation adequate to bind the soil and prevent erosion shall be replaced in excavated areas and in any other areas indicated on the site plan. The areas so covered shall be planted with legumes and/or grasses plus trees and/or shrubs if desired.

7 A pit or quarry may be rehabilitated by backfilling.

8 (a) Security in the form of a bond or certified cheque in the amount of five hundred dollars ($500) per one thousand (1000) square metres ($2000/acre) shall be posted to ensure site rehabilitation to the satisfaction of the Nova Scotia Department of the Environment. the bond or certified cheque shall be made payable to the Province of Nova Scotia and shall be submitted to the Department of the Environment.

(b) In the case of temporary pits or quarries established solely for the purpose of satisfying contractual agreements with the Nova Scotia Department of Highways the security requirement is satisified by the usual hold-back of money by the Department of Highways.

9 The security deposit referred to in Section (8) Subsection (a) shall be released upon request by the applicant and only after completion of rehabilitation to the satisfaction of the Minister.

Source: Nova Scotia Department of Environment, 1978.

APPENDIX 4. PROPOSED NOVA SCOTIA GUIDELINES FOR SURFACE MINING

Introduction

Surface mining has, in the past, been responsible for severe environmental degradation in the area of development. The purpose of this guideline is to ensure that all future surface mining operations are conducted in such a manner that the potential impact on the natural environment is clearly understood and the operation is designed to minimize adverse environmental effects. The objective of the Department of the Environment is to ensure the orderly development, operation and permanent rehabilitation of all proposed surface mining ventures in accordance with the Environmental Protection Act and the Water Act.

1. This guideline may be cited as Environmental Guidelines for Surface Mining Operations.

Part I: Interpretation

2. In this guideline

(a) "Act (s)" means the *Environmental Protection Act* and/or the *Water Act*.

(b) "Baseline Survey" means surveys or studies conducted to define environmental conditions in the proposed development region prior to mining activity.

(c) "Deputy Minister" means The Deputy Minister of the Environment.

(d) "Minister" means The Minister of the Environment.

(e) "Monitoring" means periodic or continuous documentation of effluents being discharged to the environment and the effects of those effluents on the environment.

(f) "Reclamation" means those remedial measures necessary to alleviate or eliminate conditions arising from surface mining.

(g) "Rehabilitation" means the stage of activity following reclamation, comprising land development for environmental improvement of a disturbed area.

(h) "Surface mine" means any process of removing the earth, rock, and other strata in order to uncover the underlying mineral or fuel deposit.

Part II: Requirements

3. (a) Any person contemplating a surface mining operation shall conduct or have conducted baseline surveys in sufficient detail to document the environmental condition existing on and surrounding the proposed mine site.

(b) The baseline surveys shall, at the discretion of the Minister, include all or a portion of those listed in *Appendix I* of this document but shall not necessarily be restricted to the items listed therein.

(c) The results of all baseline studies shall be submitted to the Minister as soon as possible after completion.

4. (a) The proponent shall provide the Minister with details of operating procedures and devices designed, in consideration of the baseline data described in Section 3, to protect the environment from unnecessary degradation during and following the mining operation.

(b) The Minister reserves the right to require the proponent to alter, delete, or add procedures or devices when such alteration, deletions, or additions are deemed necessary to ensure the protection of the environment.

(c) The items of concern shall, at the discretion of the Minister, include all or a portion of those listed in *Appendix II* of this document but shall not necessarily be restricted to the items listed therein.

5. (a) The proponent shall, during the mining operation, conduct or have conducted monitoring programs as specified by the Minister to document the quantity and quality of effluents being discharged or emitted to the environment and the effect of those effluents on the environment.

(b) The monitoring programs shall, at the discretion of the Minister, include all or a portion of those listed in *Appendix III* of this document shall not necessarily be restricted to the items listed therein.

(c) The results of all monitoring programs shall be submitted to the Deputy Minister on a monthly basis.

6. (a) The proponent shall provide the Minister with details of all off-site activities associated with the proposed mining operation.

(b) Off-site activities shall be operated in a manner consistent with good environmental practices and in compliance with the Acts.

(c) Off-site activities include all or a portion of those listed in *Appendix IV* of this document but are not necessarily restricted to the items listed therein.

7. (a) The proponent shall, in as far as possible, develop and submit to the Minister contingency plans to cover emergency situations.

(b) Emergency situations include all or a portion of those listed in *Appendix V* of this document but are not necessarily restricted to the items listed therein.

8. (a) Reclamation and rehabilitation shall be carried out as described in the plans submitted in accordance with Section 4.

(b) Whenever possible reclamation and rehabilitation shall be conducted on a progressive basis during the mining operation.

(c) Rehabilitated land shall be vegetated with a permanent vegetative cover or otherwise stabilized to the satisfaction of the Minister.

Part III: Appendices

I. Baseline Surveys

1. Surface water chemistry;
2. Surface water hydrology;
3. Surface water biology;
4. Groundwater chemistry;
5. Groundwater hydrology;
6. Atmospheric quality;
7. Normal sound levels;
8. Normal vibration levels;
9. Fauna-flora biology;
10. Soil chemistry;
11. Existing topography;
12. Geology;
13. Historical value of area;
14. Existing sources of domestic and industrial water;
15. Existing domestic and industrial waste disposal methods;
16. Present land use of site.

II. Environmental Control for Mining Operation

1. Management and control of surface water, mine water, and process water;
2. Prevention and/or control of seepage;
3. Protection of aquatic and terrestrial ecosystems;
4. Control of aerial emissions;
5. Noise and vibration control;
6. Backfilling plans;
7. Rehabilitation and landscaping plans;
8. Plans for control of excessive illumination of the site;
9. Storage of fuels and disposal of lubricating oils;
10. On site storage of chemicals and hazardous materials.

III. Environmental Monitoring During the Mining Operation

1. Effluent quantity and quality;
2. Surface water quantity and quality;
3. Groundwater quality;
4. Groundwater hydrology;
5. Atmospheric quality;
6. Sound and vibration;
7. Monitoring of aquatic and terrestrial ecosystems.

IV. Off-site Activities

1. Transportation methods;
2. Traffic patterns and density;
3. Construction and maintenance of traffic corridors;
4. Sewage disposal and water supplies for off-site facilities;
5. Off-site product storage.

V. Contingency Plans

1. Landslides;
2. Disruption of local services; including water, sewage and power; attributable to mining related activities;
3. Flood control;
4. Explosion

Source: Nova Scotia Department of Environment, 1978

APPENDIX 5. GUIDELINES FOR ENVIRONMENTAL CONTROL IN THE ONTARIO MINERAL INDUSTRY: ABANDONMENT

Part D: Abandonment

Guidelines in this section are intended to apply to mine-mill properties when they are to be abandoned.

D-4. All mine-mill structures should be completely dismantled. The resulting material should be removed from the property or should be disposed of in a suitable manner.

D-2. All mine-mill machinery etc., should be removed from the property or, if this is not practicable, should be collected and disposed of on the property in a suitable manner. All such waste, for instance, could be collected in a common area and covered with soil (spoil from the pit area etc.) The resulting mound could be easily revegetated. Perhaps this type of waste could be taken to a gravel pit etc., on the property and, at a suitable time, could be buried. Any small open pits on the property could serve as burial areas.

The possibility of groundwater contamination should always be kept in mind when waste materials are to be buried.

D-3. Whenever and wherever possible and practicable, waste rock or, in general, spoil piles should be graded to below mature tree level. Where this is impossible, waste piles should be kept as low as possible.

D-4. Where garbage from a townsite etc., has been permitted to accumulate, the garbage should be covered with earth and revegetated before the property is abandoned.

D-5. Tailings areas, tailings dams, waste rock dumps, and mill sites etc., should be revegetated in an approved manner.

Source: Ontario Ministry of Environment. 1981. p.16-17

APPENDIX 6. GUIDELINES FOR RECLAMATION OF LAND IN ALBERTA

Introduction

The legislative authority governing the preparation and submission of applications for Development and Reclamation Approvals and for reclamation inquiries is contained in The Land Surface Conservation and Reclamation Act, 1973, and in the Land Conservation Regulation filed as Alberta Regulation 125/75 as amended and various Regulated Surface Operation Regulations made under that Act. The Act and the Regulations specify factors to be included in the application, but leaves the detailed contents of the application to the applicant.

Section 35 of the Act provides for the making of regulations which prescribe the standards of criteria to be used by the Land Conservation and Reclamation Council in determining whether the disturbed land surface has been satisfactorily reclaimed. In the absence of regulations, Section 36 allows the use of standards satisfactory to the Council.

It is the Council's opinion that regulations at this point in time would be too inflexible for satisfactory application and that more flexible guidelines would be more applicable.

The attached 'Guidelines for the Reclamation of Land Affected by a Surface Disturbance' are intended to be an expression of the Land Conservation and Reclamation Council's expectations with respect to the detailed content of applications for approvals of surface disturbances and the reclamations of lands and will until further notice take the place of regulations under Section 35.

Source: Alberta Land Conservation and Reclamation Council, 1977.

Guidelines for the Reclamation of Land Affected by a Surface Disturbance

Since the implementation of The Land Surface Conservation and Reclamation Act, questions pertaining to the reclamation of disturbed lands in Alberta, and increasing concerns over the land use after the conclusion of the disturbance, have resulted in:

(a) a re-evaluation of various concepts of soil science, range ecology, and land use that have formed the basis of land management philosophies in the past, and

(b) the adoption of requirements for long term planning relating to the conservation of soil, water, air, and associated biota

to assure as a goal to the return to, or the continuation or resumption of some appropriate land use upon the conclusion of the surface disturbance.

As a result of the re-evaluation, the concept of "reclamation" of land has been defined as including all desirable and practicable methods for:

(a) designing and conducting a surface disturbance in a manner that minimizes the effect of the disturbance and enhances the reclamation potential of the disturbed lands;

(b) handling surficial material in a manner that ensures a root zone that is conducive to the support of plant growth where required for future use;

(c) contouring the surface to minimize hazardous conditions, to ensure stability, and to protect the surface against wind or water erosion;

(d) Although the loss and re-establishment of groundwater acquifers is a major consideration in reclamation technology, present knowledge does not permit specifying guidelines other than stating an objective of replenishing of the groundwater source for beneficial use.

The "Reclamation Criteria", hereinafter attached as Appendix 1, are based on the foregoing conceptual considerations.

The Criteria and the "Guidance Document for Preparation of a Reclamation Plan", hereinafter attached as Appendix 2, are intended to guide the proponent of any surface disturbance to which The Land Surface Conservation and Reclamation Act applies:

(a) in planning the operation that will result in the surface disturbance in a manner that will minimize the effect of the disturbance after the conclusion of the disturbance,

(b) in describing, in its application for a Development and Reclamation Approval under the Act, how it proposes to reclaim the disturbed land upon the conclusion of the operation, and

(c) in performing the reclamation of the land as required under the Approval, the Act and the regulations thereunder.

The Criteria, concurrently will be applied:

(a) by the approving authorities under the Act and regulations in the review of applications for a Development and Reclamation Approval;

(b) by the members of the Land Conservation and Reclamation Council in exercising their authority and discretion while conducting inquiries to determine whether land to which the Act applies has been reclaimed in accordance with the applicable Development and Reclamation Approval, including the Development and Reclamation Plan, the Act and the regulations, and

(c) by the members, Chairman and Deputy Chairmen of the Council when deciding whether or not to issue reclamation certificates or reclamation orders.

Appendix 1: Reclamation Criteria

General

1. (1) In these Guidelines,

(a) "Act" means The Land Surface Conservation and Reclamation Act;

(b) "Approving Authority" includes the Land Conservation and Reclamation Council;

(c) "Land Conservation Regulations" means Alberta Regulation 125/74 as amended from time to time and any regulations made in substitution therefore;

(d) "Regulated Surface Operation Regulations" means any regulation designating any operation or activity named in Section 23 (1) of the Act to be a regulated surface operation pursuant to that section.

(2) Any expression that is defined in the Act, the Land Conservation Regulations, any Regulated Surface Operation Regulations, and any applicable Exploration Approval or Development and Reclamation Approval has the same meaning herein.

2. Disturbed lands shall be reclaimed to the condition and to achieve the post-disturbance land use that is prescribed:

(a) in the Development and Reclamation Approval issued in accordance with the applicable Regulated Surface Operation Regulations, or

(b) in the absence of an Approval, or other specified conditions, by the Council following consultation with the owner or operator, or both of them, as the case may require, or

(c) in the contractual agreement, lease or license of occupation agreed to between the owner (public and private lands) and the operator.

Drainage and Erosion Control

1. Water from catchment areas adjacent to the lands to be disturbed shall not be routed through the lands unless the operator takes precautions that in the opinion of the Approving Authority are adequate to prevent siltation and erosion of the lands to be disturbed.

2. Streamflows in and through natural drainage systems located on the lands to be disturbed shall be maintained by the operator through the installation of culverts or bridges, or the construction of interceptor or drainage ditches or other drainage systems that in the opinion of the Approving Authority are adequate to accommodate seasonal streamflows.

3. All interceptor or drainage ditches constructed by the operator shall have outlets consisting of natural drainage ways, vegetative areas or other stable watercourses that convey runoff without causing erosion.

4. Where erosion is liable to occur, the operator shall construct diversion ditches, that in the opinion of the Approving Authority are adequate to ensure that the lands to be disturbed are protected from erosion.

5. (1) The operator shall ensure that drainage from disturbed lands, under normally prevailing seasonal climatic conditions, shall only be discharged in accordance with Alberta Environment's surface water quality objectives or other methods prescribed by the Approving Authority to a recieving stream or other water-course described in the Guidelines or prescribed method.

(2) When directed by the Approving Authority, the operator shall cause to be designed and constructed any settling ponds or other facilities that may be necessary to settle sediments from run-off that is equivalent to at least a ten year flood condition, to the extent that the total suspended solids content in any water discharged from the settling pond or other facilities will not exceed the concentration permitted by the Approving Authority.

Conservation of Materials for Reclamation

1. (1) Where, before the approved land disturbance, soil horizons on the lands to be disturbed are sufficiently well developed to support plant growth or in the opinion of the Approving Authority to be capable of supporting plant growth, the soil horizons shall be selectively removed in the manner prescribed by the Approving Authority.

(2) Whenever it is necessary to store soil and other surficial material suitable for reclamation, the geotechnical foundation of areas used by the operator for storage shall be stable and the storages areas shall be protected from wind and water erosion.

(3) The operator shall use all soil and surficial material suitable for reclamation to perform the reclamation in the manner prescribed by the Approving Authority.

Backfilling and Recontouring

1. Any material that is toxic to plants or animals, or in the opinion of the Approving Authority may be toxic to plants or animals, shall be disposed of by the operator by burial below the root zone or in the manner described in the Approval for the disturbance or as may otherwise be prescribed by the Approving Authority, at a location where groundwater quality will not be adversely affected.

2. Highwalls, footwall, embankments and slopes shall be reduced or backfilled and graded as closely as possible to the same contours as the contours that existed before the disturbance and to a slope not greater than 2:1 unless the Approving Authority otherwise prescribes.

3. All excavations shall be filled and reclaimed to the contours prescribed in the applicable Approval or as determined by the Approving Authority in consultation with the owner, having regard to the prescribed post-disturbance land use.

4. (1) Where the prescribed post-disturbance land use is agricultural production, the operator shall grade the land:

(a) as closely to the same contours as the contours that existed before the disturbance, and

(b) to a slope, wherever possible, not greater than 5:1, but all contouring shall allow for soil subsidence and erosion control

(2) Where the prescribed post-disturbance land use is a use requiring irrigation, the operator shall grade the land as closely to the same contours and slope as the contours and slope that existed before the approved surface disturbance, or to contours and slope that are equivalent to the contours and slope of irrigated lands in areas adjacent to the reclaimed lands.

(3) Where the prescribed post-disturbance land use is commercial timber production, the operator shall grade the land:

(a) as closely to the same contours as the contours that existed before the approved surface disturbance, and

(b) to a slope, wherever possible, not greater than 3.5:1.

(4) Where the prescribed post-disturbance land use is a use other than agricultural or commercial timber production, the contours and maximum slopes of the reclaimed lands shall not exceed equivalent contours and maximum slopes on lands in areas adjacent to the disturbed lands or as otherwise prescribed by the Approving Authority.

Restructuring of the Root Zone

1. (1) Where the prescribed post-disturbance land use is agricultural production, the operator shall place root zone soil, having a depth that is sufficient to support agricultural plant growth, in proper sequence, on the surface of the reclaimed lands.

(2) Where the prescribed post-disturbance land use is a use other than agricultural production, the operator shall place soil or other plant-supporting materials on the surface of the reclaimed lands so that a restructured soil, having a depth, and chemical and physical characteristics suitable and sufficient for supporting plant life, is available to achieve the prescribed post-disturbance land use.

(3) Where sufficient soil or other surficial plant-supporting materials is available, the operator shall provide a root zone having a depth at least equal to the depth of the rooting zone of the plants that are being used in the reclamation process.

Revegetation

1. When required by the Approving Authority, the operator shall, as soon as practicable following placement on the lands of soil or other surficial plant-supporting material, seed or plant on the reclaimed lands, suitable plant species in the manner and to the extend prescribed by the Approving Authority in consultation with the owner.

2. (1) Where the prescribed post-disturbance land use is the establishment of permanent forest vegetation, the operator shall establish an initial vegetative cover that will not inhibit forestation that is achieved through the growth of approved tree species, through the invasion of native tree species, or through other forestation techniques or methods.

(2) The operator is responsible for the establishment of such additional indigenous plant species as may be necessary to achieve a self-sustaining forest plant community.

3. Where the prescribed post-disturbance land use is the establishment of permanent forest vegetation for commercial timber production, the operator is responsible for the establishment, in a manner prescribed by the Alberta Forest Service Regeneration Survey Manual, of a minimum of 320 established seedling trees as defined in the Timber Management Regulations, per acre of commercial tree species satisfactory to the Approving Authority.

4. Where the prescribed post-disturbance land use is the establishment of permanent vegetation suitable for wildlife habitat, the operator is responsible for the establishment of various species and numbers of trees, grasses, forbs and shrubs of a density and composition which will provide food and cover for wildlife, consistent with the ecological zone of the region and satisfactory to the Approving Authority.

Restoration or Services and Utilities

1. All survey monuments established under The Alberta Surveys Act and all roads and public utilities established before the approved surface disturbance shall be maintained or replaced by the operator as prescribed by law and by the Approving Authority.

2. All domestic, municipal, irrigation and other agricultural water supply systems established before the approved surface disturbance shall be maintained or re-established by the operator to provide a level of service at least equivalent to that which existed prior to disturbance.

3. Access roads and haul roads that in the opinion of the Approving Authority, in consultation with the owner, are no longer necessary, shall be reclaimed by the operator in the manner prescribed by the Approving Authority.

Aesthetics and Safety

1. The operator shall leave the reclaimed lands in a state free of unnecessary structures and equipment, and shall landscape the lands so that they are aesthetically satisfactory to the Approving Authority.

2. The operator shall leave the reclaimed lands in a safe condition, free of:

(a) all hazards including any open excavations, unstable highwalls, footwalls, embankments or slopes;
(b) any hazardous substances including explosives and toxic or radioactive materials, and
(c) any garbage, debris or other waste materials.

Land Management

1. Where the prescribed post-disturbance land use is agricultural production, the operator shall remain responsible for the maintenance of the reclaimed land during the period of time that is required to demonstrate that the agricultural productivity of any soil placed by the operator on the reclaimed lands is comparable:

(a) to the agricultural productivity that existed prior to the surface disturbance, or
(b) where the pre-disturbance use of the land was not agricultural production, to such other productivity standard as the Approving Authority may prescribe.

(2) Where the prescribed post-disturbance land use is a use other than agricultural production, the operator shall remain responsible for the maintenance of the reclaimed lands until:

(a) the soil surface has been stabilized and the composition, density, growth and vigor of vegetation established by the operator is comparable to the composition, density, growth and vigor of vegetation that existed before the surface disturbance, or
(b) the condition of the land is comparable to the condition of other similar lands that have been reclaimed in a manner satisfactory to the Approving Authority.
(c) 320 established seedling trees per acre are growing on the site without assistance when the prescribed post-disturbance land use is commercial timber production.

Appendix 2: Guidance Document for Preparation of a Reclamation Plan

The primary objective in land reclamation is to ensure that the mined or disturbed land will be returned, wherever possible, to a state which will support plant and animal life, or be otherwise productive or useful to man, at least to the degree it was before it was disturbed, as described in the *Guidelines for the Reclamation of Land Affected by a Surface Disturbance*.

A Reclamation Plan for lands to be mined normally includes seven components, namely:

1) Site Analysis and determination of post-disturbance land use
2) Surface Hydrology Analysis
3) Overburden Analysis
4) Mining Plan Analysis
5) Post Mining Land Use Plan
6) Materials Handling Plan, and
7) Revegetation Plan

The interrelationship of these components is shown on Figure 1. Other disturbance may not include all seven of the components.

Site Analysis

The productive capability of the land and its existing uses should be determined. Investigators should include an analysis of soil, vegetation, fish and wildlife and any unique features.

Surface Hydrology Analysis

This includes the identification of the surface drainage patterns including lakes, streams, and sloughs and the recording of mean annual flows.

Overburden Analysis

This is the determination of the chemical and physical characteristics of the overburden and the bedrock that would be used in the reclamation program. The information is used to prepare a detailed overlay or map showing the aerial extent and volume of overburden available for placement in the root zone.

Mining Plan Analysis

The information required from the mining plan is the determination of the total volume of overburden to be mined, the volume of overburden to be stored, for subsequent backfilling and root zone development, and the volume of overburden that will be placed in discard areas.

Post Mining Land Use Plan

Once the analyses have been completed and the volumes of the overburden materials in the mining plan are known, a potential land use plan can be prepared. The overlay or map should clearly show the anticipated topographic contours, the roads, utilities, location and area of lands to be reclaimed for agriculture, commercial timber, or wildlife habitat, including the location of streams, rivers, lakes and sloughs.

Materials Handling Plan

The materials handling plan should account for the use of all mined and/or excavated material on the site including the material used for backfilling, interim storage, dyking, landscaping or discard.

The plan should indicate the depth and type of overburden that will be used to form the root zone. It should describe the sequence, timing and method that will be used for the replacement of overburden and root zone material.

Revegetation Plan

The revegetation plan should describe the method and time frame required to manage and maintain the initial vegetative cover to obtain soil productivity or a self-sustaining plant community which will develop into a predetermined agricultural, forest, wildlife, or other use of at least equal productivity that existed prior to disturbance.

The plan should identify and describe the combination of plant species to be used, methods of seedbed preparation, the time, methods and rates of seeding and fertilization. Where site specific information is not available test plots may be necessary to determine the most practical treatment.

General

Depending upon the nature of the project, the applicant may also be required to submit additional soils, geology, groundwater, and geotechnical reports, where solutions to specific problems are required.

Reclamation plans shall be based on the use of the best applicable technology. Plans shall be prepared by qualified professionals in the appropriate fields of endeavour.

RECLAMATION PLAN PREPARATION

CONCEPTUAL FLOW DIAGRAM

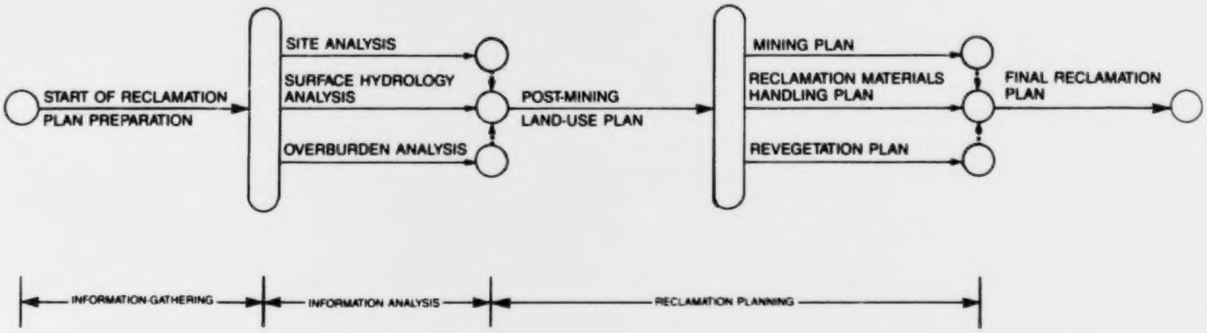
START OF RECLAMATION PLAN PREPARATION
SITE ANALYSIS
SURFACE HYDROLOGY ANALYSIS
OVERBURDEN ANALYSIS
POST-MINING LAND-USE PLAN
MINING PLAN
RECLAMATION MATERIALS HANDLING PLAN
REVEGETATION PLAN
FINAL RECLAMATION PLAN
INFORMATION GATHERING
INFORMATION ANALYSIS
RECLAMATION PLANNING

FIGURE 1

APPENDIX 7. BRITISH COLUMBIA RECLAMATION GUIDELINES

I. Guidelines for Metal and Coal Mine Anbadonment

(A) When a mine is shutdown and the entire plant is left on the property it shall be considered a temporary shutdown. Reclamation of the disturbed areas shall be done on the basis determined by the Reclamation Section of the Ministry of Energy, Mines and Petroleum Resources.

(B) Where a mine is shutdown and the mine plant removed the following shall be done:

General

(1) The mining company shall submit to the Senior Reclamation Inspector a plan of total reclamation prior to shutdown.

(2) All buildings, machinery, mobile equipment shall be removed. All scrap material shall be disposed of in a manner mutually acceptable to the Ministry of Energy, Mines and Petroleum Resources and the mine operator.

(3) Concrete foundations and slabs may be left intact and covered by overburden and revegetated where practical.

(4) All provisions of either the Mines Regulation Act or Coal Mines Regulation Act shall be complied with to the satisfaction of the District Inspector or Resident Engineer.

Tailings ponds

(1) A plan shall be submitted showing the proposed drainage controls for the tailings pond and surrounding drainage area.

(2) Where necessary a permanent spillway is required on or adjacent to the tailings dam to provide for excessive run-off water. Details and design shall be submitted to the Chief Inspector of the Ministry of Energy, Mines and Petroleum Resources and the District Inspector for Approval.

(3) Where practical the tailings pond shall be revegetated to a condition approved by the Reclamation Section of the Ministry of Energy, Mines and Petroleum Resources. If vegetation is to be established, it shall be done to a point where no maintenance of the vegetation is required. A minimum of three years experience is necessary to determine the quality of vegetation.

(4) Land use of the disturbed areas following mine abandonment shall be mutually agreed upon by the Ministry and the mine operator and shall take into consideration the use of the land prior to mining and the capability of the disturbed soil and/or mine waste to sustain the pre-mining land use.

Waste Dumps — Metal

(1) Where possible waste dumps should be sloped to an angle where vegetation can be maintained. If overburden is available, flat areas of the dumps shall be covered to a depth of three to six inches of overburden or top soil.

(2) All flat areas on the dumps shall be revegetated and vegetation shall be established to a point where no maintenance is required. A minimum of three years experience is necessary to determine the quality of vegetation.

(3) A plan of the drainage area surrounding the dumps shall be submitted to the Senior Reclamation Inspector. Where possible all drainage should be directed away from the dumps.

(4) Ultimate land use of the disturbed dump area shall be specified.

Waste Dumps — Coal

(1) Final slope of coal waste dumps shall be 26 degrees or at an angle where the dump is physically stable and vegetation can be maintained on the slope of the dumps.

(2) All coal waste dumps shall be revegetated to a point where vegetation is free of maintenance.

(3) A plan of the drainage area surrounding the dump area shall be submitted to the Senior Reclamation Inspector. Where possible all drainage should be directed away from the dumps.

(4) Ultimate land use of the reclaimed dumps shall be specified.

(5) A minimum of three years is necessary to determine the quality and the permanence of the established vegetation.

Pit Area

(1) Pits shall be backfilled whenever possible.

(2) A plan shall be submitted to the Senior Reclamation Inspector showing how the pit area shall be left after completion of mining.

(3) Where the pit area is going to be designated as a lake, a report shall be submitted to the Senior Reclamation Inspector outlining source of water, drainage area, maximum level of water, water quality, access to lake, plans for stocking of the lake.

(4) Where the pit floor will be free from water, where possible overburden shall be used to provide sufficient cover to establish vegetation.

(5) Pit walls shall be left in a safe manner to the satisfaction of the District Inspector of Mines.

Source: McDonald, J. D. 1978. p.73-76

II. Guidelines for Reclamation of Quarry Operations

The general intent of these guidelines is to minimize the impact of quarrying on the existing environment and to ensure that the land is restored to a suitable land use following mining.

During Mining

1. Strip and stockpile all overburden and topsoil (rooting depth). Topsoil muist not be taken from the property.

2. Control drainage by use of diversion ditches and settling ponds.

3. Progressively reclaim abandoned portions of the quarry.

4. At the discretion of the District Inspectors, buffer zones may be required between the operations and the property boundary to alleviate noise and dust.

Before Quarry Abandonment

1. An abandonment plan must be submitted and approved by the Chief Inspector of Mines. Operators are encouraged to develop innovative uses for abandoned quarries. Some examples of quarry uses are: agricultural land, forest land, picnic sites, recreation areas, christmas tree farms, residential developments, industrial developments, water storage reservoirs, and rifle ranges.

2. Where alternative uses have not been approved the land shall be left in a condition satisfactory to the Chief Inspector of Mines according to the following:
   (1) Waste dumps and refuse piles shall be recontoured to a maximum slope of 26 degrees, covered with overburden or topsoil and revegetated.
   (2) All buildings and equipment must be removed from the site.
   (3) Concrete foundations and slabs may be left intact but must be covered with overburden and revegetated.
   (4) Roads shall be ripped and covered with overburden and revegetated.
   (5) Permanent system of drainage control must be established.

Notes Pertaining to Quarry Operations

Note 1: Ownership

When the operator of the quarry is not the registered owner of the property (surface of the land under the *Land Act*), then the name and postal address of the registered owner is to be shown. In this situation, a letter is required from such registered owner acknowledging that he is aware of and approves the content of the Form 10-11. (This letter is not required in the case of quarries held under lease from the Crown.) The owner must put up the bond for reclamation of the operation, so it is in his interest to be aware of the condition of the property and extent of the works.

Note 2: Topsoil

Topsoil is defined as extending to maximum root penetration. Topsoil must not be taken from the property; it is to be conserved for use in the reclamation program. Topsoil is to be removed from operational areas prior to any disturbance of the land, and stockpiled separately on the property.

Note 3: Watercourses and Watertable

If watercourses are to be disturbed in any manner by the operations, prior application must be made to Water Rights Branch for a licence under the *Water Act*, and to the Pollution Control Branch for a permit under the *Pollution Control Act* if washwater is used.

When a quarry has been extracted to below the watertable, thereby forming a residual pond, the Chief Inspector may require that backfilling, drainage, and/or bank contouring measures be carried out, to complement reclamation.

Note 4: Condition of the Land and Future Use After Reclamation

A wide variety of usage may be made of quarries, after the rock has been extracted, such as picnic sites, parks, recreation areas, Christmas tree farms, farm lands, residential or industrial development, etc. The reclamation program will be carried out as soon as the usage of the land, or any substantial part of it, for mining purposes has been terminated. Pit banks, berms, benches, and hummocks shall be graded to a gently undulating surface, using waste and overburden as required to achieve this condition. The stockpiled topsoil shall be evenly distributed over the disturbed and regraded areas. All areas shall then be re-vegetated to the most suitable type of vegetation, relevant to the nature of and the location of the land.

Plant and buildings are to be completely removed, and the foundations backfilled or covered, at the termination of operations, except with the written approval of the Chief Inspector of Mines.

The land shall be left in a neat, clean, and safe condition.

Note 5: Aesthetics and Public Safeguarding

The *Mines Regulation Act* provides for the safeguarding of the public [see section 7(1)]. It also regulates the distance from the property boundary within which excavation operations shall not be carried out [see section 23, Rule 253(a)]. The Inspector may require that a suitable screen of trees, shrubs, etc., be left or be established between the operations and the property boundary, when such boundary abuts on a playground, park, residential development, main highway, or other area open to the public at large.

Source: British Columbia Ministry of Energy, Mines and Petroleum Resources, 1981.

APPENDIX 8. SASKATCHEWAN DRAFT SURFACE RECLAMATION REGULATIONS

The Development and Reclamation Plan

10. The operator shall submit a development and reclamation plan acceptable to the department. Such development and reclamation plan will form part of the application for a surface excavation permit and must contain, but is not limited to, the information required in sections 11, 12 and 13 of these regulations.

11. The development and reclamation plan shall include:

(1) On a map to a representative scale of 1:2000, or such other scale acceptable to the department:

- (a) the legal boundaries of the site,
- (b) location, quality and quantity of the reserves to be developed,
- (c) the depth, type and volume of overburden, including identification of soil type and any strata unsuitable for reclamation,
- (d) the thickness of the deposit,
- (e) the location of any existing and proposed buildings, structures, and machinery,
- (f) the ground water levels of the site, including the existing water table and any producing aquifers within 10 metres of the ground surface,
- (g) the proposed location of all stripped overburden,
- (h) the location and means of construction of access and haul roads,
- (i) the location and nature of any waste deposit from any processing,
- (j) the exact area to be cleared of vegetation and the type of vegetation to be cleared,
- (k) the exact area in which physical disturbance of the surface will be made,
- (l) the location and names, if any, of all surface water bodies, roads, railroads, recreation areas, residential areas and utility facilities within or adjacent to the site,
- (m) the locations and logs of any exploratory drilling and test pitting,
- (n) the existing drainage patterns and the proposed drainage patterns during and following the operations.

(2) On a map to a representative scale of 1:10,000 or such other scale acceptable to the department: the location, depth, age, diameter, and water level of all water wells and the location and size of all dugouts, within a 2000 metre radius of the site, or such greater distance as may be requested by the department.

12. The development and reclamation plan submitted with the application for a permit shall provide a detailed description of:

- (a) the procedures to be followed and type of equipment to be used in opening up, extracting and any processing.
- (b) a sequential schedule of all activities engaged in the opening up, operation, development and reclamation that includes (i) the simultaneous interrelationships of operation, development and reclamation, (ii) the estimated planned sequential rate of production, including the volume, (iii) the overall duration of the operation.
- (c) measures to be employed for protection of the public from steep banks, deep holes, and other hazards peculiar to operations of this type.
- (d) measures to be employed in the visual screening of the operation,
- (e) measures to be employed for dealing with standing water either by draining of the pit, filling in, or other approved practices,
- (f) measures to be employed to ensure proper site drainage,
- (g) the procedures to be applied in the operation to control the discharge of contaminants and disposal of refuse.

13. The development and reclamation plan accompanying the application for a surface excavation permit shall provide a detailed reclamation program which shall include:

- (a) the time and sequence schedule to be followed,
- (b) the physical and biological methods to be used,
- (c) the anticipated final condition and subsequent use of the reclaimed site,
- (d) where revegetating is being proposed, the applicant shall identify the types of vegetation to be used and the means of their establishment,
- (e) the scheduling of revegetating and the procedures to be used in the subsequent nurturing of it in its initial growth stages,
- (f) plans illustrating completed reclamation of each stage which show all details,

(g) cross sections, where necessary, to show ultimate reclamation,

(h) provision for removing structures, equipment, stockpiles and refuse from the permit area,

(i) for reasons of public safety, provision of subsurface benches around all bodies of standing water. Such benches shall not be more than 0.6 metres below normal water level and not less than 1.5 metres wide around the entire perimeter of all bodies of standing water which are more than one metre deep,

(j) evidence, in written form, stating that all owners of a legal, equitable, fiduciary or possessory interest in the land concur with the proposed subsequent use for the site. Such evidence shall be witnessed and/or notarized.

(k) Such other information as the department may require or as is prescribed by the regulations.

Bond Required

14. (1) Before issuing or reissuing a surface excavation permit the department shall require that the applicant for such permit file with the Minister of Finance a bond, conditioned upon the faithful performance of the development and reclamation plan and of the other requirements of these regulations in a sum equal to $50/100 square metres of land to be affected under the terms of the permit, or a sum as may from time-to-time be determined by the Minister.

(2) The operation may be suspended if the bond is not maintained.

(3) Nothing in this section shall apply to any federal or provincial government agency.

15. (1) Upon request of the permittee, and when in the judgement of the department the reclamation has been completed in accordance with the regulations and the development and reclamation plan, the permittee shall be notified that the work has been found to be satisfactorily performed and is acceptable and his bond shall be returned.

(2) All or a portion of any bond may be withheld where the department requries additional time to determine the effectiveness of the reclamation work.

Development and Reclamation Plan Binding

16. Every operator shall carry on his operations in accordance with the development and reclamation plan upon which his permit is based and the operator may amend the development and reclamation plan with the consent of the Minister.

Review of an Operation

17. The department may, from time-to-time, review the operation of a permittee and may cause the permit area to be inspected for the purpose of assessing the compliance of the permittee with these regulations, the development and reclamation plan and the terms and conditions of the surface excavation permit.

Failure to Comply with Development and Reclamation Plan

18. If from inspection, or from any other source, it is determined that the permittee has not or is not complying with the development and reclamation plan or the regulations, the department shall give written notice thereof to the permittee, specifically outlining the deficiencies. Within thirty days thereafter, the permittee shall commence action to rectify those deficiencies and diligently shall proceed until they are all corrected.

19. Where the reclamation program of a site is not carried out in accordance with the requirements of these regulations and the development and reclamation plan or the terms and conditions of the surface excavation permit, the Minister may direct that the bond be forfeited and the surface excavation permit cancelled.

20. If, under section 19, the security is forfeited the Minister may authorize any person or persons to enter upon the site and perform such work as is necessary to complete the reclamation requirements, and the cost thereof shall be paid out of the monies forfeited and the balance refunded.

Isolation Distances

21. All stockpiles, buildings, structures and excavations shall be at least 30 metres from abutting property boundaries, 80 metres from habitable residences and 50 metres from the centre lines of public roads, or such other greater distance as may be specified by the department.

Fencing

22. Before commencing any excavation, the operator shall, if so directed by the department, erect a heavy duty fence consisting of not less than three strands of barbed wire attached to treated wooden or steel poles which shall follow the contours of the surface of the ground on the perimeter of the area to be excavated as indicated on the site plan. If the site is fenced, gates shall be on all access roads and shall be locked when the site is not in use. Such fencing and gates shall be maintained in good condition.

Reclamation

23. **(1)** Unless otherwise approved, the site shall be returned as close as possible to the final grade and contours indicated in the development and reclamation plan with slopes not exceeding 18 degrees.

(2) Unless otherwise approved, reclamation shall commence while the pit is in operation.

(3) Reclamation shall be completed within three years of the closure of the site.

24. **(1)** Subject to section 21, top soil shall be stockpiled during operations, then spread evenly over the surface following restoration of the slopes.

(2) Unless otherwise approved vegetation shall be re-established and nurtured on the site. Where perennial grasses are approved they shall cover at least 95 per cent of the land to be reclaimed. Bare areas shall be less than 100 square metres in size and shall not total more than five per cent of the total area.

(3) Where a site had significant tree and/or shrub growth, it shall be re-established as much as practicable.

Miscellaneous

25. Except as provided in sections 9 and 14, the Crown is bound by these regulations.

26. The burden of proof for the determination of the "period of 12 consecutive calendar months" rests with the operator. Operators wishing to avail themselves of the exemptions provided in section 3, with respect to the 8000 cubic metres or the affecting of 8000 square metres of land should voluntarily provide the department with information including, but not limited to, the name of the operator, location of the site, date of commencement of the operation, and annually a summary of the previous 12 months of operation. Operations classed as exempt by the department are not subject to the payment of fees, posting of bonds or filing of development and reclamation plans unless the minimum quantities or areas or combination thereof, as provided in this section, are exceeded.

Penalties

27. Every person who contravenes the regulations is guilty of an offence and liable on summary conviction to the penalties as set out in section 14 of *The Department of the Environment Act*, 1972.

28. These regulations shall come into force on January 1, 1977.

29. These regulations shall not apply to land affected prior to January 1, 1977.

Source: Saskatchewan. Department of Environment. 1977. Regina. p.5-10.

APPENDIX 9: SASKATCHEWAN DRAFT URANIUM MINING REGULATIONS: RECLAMATION AND ABANDONMENT

Reclamation and Abandonment

17. The owner or operator of a mine or mill shall submit for the approval of the department, at least twelve months prior to the planned ceasing of operation of any mining works, a detailed reclamation and abandonment plan for the mining works and waste materials.

18. The owner or operator of a mine or mill shall, prior to the abandonment of a mining works, provide for the stabilization and reclamation of all mining works and waste materials, to minimize the release of materials that could cause pollution.

19. If required to prevent pollution of the environment, the owner or operator of a mine or mill shall provide for the continued operation and maintenance of any mining works that will reduce the release of contaminating substances into the environment.

20. Unless otherwise approved by the Minister, the owner or operator of a mine or mill, shall commence reclamation and abandonment procedures within one month of shut-down of the mine, mill or mining works and shall complete reclamation and abandonment procedures within five years of the shut-down in accordance with the following:

a) in general, the owner or operator of a mine or mill, upon shut-down of a mine, mill or mining works shall:
   i) remove from the site all buildings, machinery, and mobile equipment,
   ii) burn or bury, as approved by the department, all scrap material and refuse,
   iii) seal with concrete or other suitable material, as approved by the department, all drill holes, adits, shafts, breakthroughs to surface or other holes into the ground surface,
   iv) unless otherwise approved by the department, backfill and level all pits, trenches, and other excavations on the site.

b) upon shut-down of a mine, the owner or operator of the mine shall stabilize the waste rock sites by:
   i) levelling and sloping the areas so that vegetation can be established and maintained,
   ii) if required by the department, covering the waste rock with overburden, topsoil or other suitable material to provide a medium for vegetation.
   iii) establishing a fully self-sustaining vegetative cover, and
   iv) providing diversion of fresh waters away from the site.

c) upon shut-down of a milling operation, the owner or operator of the mill shall:
   i) remove all machinery, buildings, tanks, pipes and other facilities at the mill site,
   ii) decontaminate or remove the foundations, and soils in the area, and
   iii) level the area and establish a fully self-sustaining vegetative cover over the mill site area.

d) unless otherwise approved by the Minister, upon shut-down of a milling operation or waste management facility, the owner or operator of the mill shall stabilize and reclaim the waste management facility by:
   i) providing drainage controls to limit fresh water into the waste management facility to direct precipitation,
   ii) removing as much surface water from the facility as possible and providing for drainage such that there is no permanent water pond over the solid waste materials,
   iii) providing for monitoring of any seepage or discharge from the facility, and providing for treatment of any seepage or discharge from the facility, if the levels of substances in the water are above the maximum monthly mean concentrations as listed in Schedule 1,
   iv) grading of the solid waste material and covering with sufficient soil, overburden, or other

material to result in a calculated surface exhalation of radon from the tailings of less than 2pCi/m²-sec, (cover of no less than 3 metres and of material the same as surrounding soils, as far as radioactivity is concerned),

v) providing a fully self-sustaining vegetative cover over the cover materials and tailings,

vi) providing wind and water erosion control on any sloped surfaces such as embankments (rip-rap and/or vegetative cover);

vii) providing barriers (fences) and notification to limit access to the area by the public.

21. If the owner or operator of a mine or mill fails to provide the measrues required as per section 20 the department may undertake or cause to be undertaken, whatever measures deemed to be necessary to undertake the measures and to minimize the release of materials that could cause pollution and to stabilize and reclaim the areas; and the department may recover the costs incurred, from the owner or operator of the mine or mill.

Source: Saskatchewan Department of Environment, 1982. p.9-11.

APPENDIX 10: MANITOBA GUIDE FOR PREPARATION OF REHABILITATION PLANS

Part I — Submission of Rehabilitation Plan

The objectives of the Quarry Rehabilitation Program may be summarized as follows:

1. To ensure that each commercial quarry is developed and operated in a manner that will minimize adverse impacts on the surrounding environment.
2. To abate hazards to the public caused by mining operations such as unstable slopes, steep banks, and open water excavations.
3. To return the area disturbed by mining operations to a useful purpose compatible with the surrounding environment.

Subsidiary objectives included:

1. To promote the efficient utilization of the non-renewable resource.
2. To encourage, during the mining operation the effective and efficient use of equipment and materials in the shaping of land forms required for final rehabilitation.

The Rehabilitation Submission

In order to assess whether a proposed quarry operation may meet the above objectives, Manitoba Regulation 226/76 requires the submission in duplicate of a plan of rehabilitation. This plan should show essentially an organized approach to mining of the aggregate material with progressive rehabilitation of the area to provide a compatible and useful purpose for the land on termination of the operation.

The rehabilitation plan to be submitted consists of the following items:

1. Cash Deposit:
   A cash deposit is required to provide funds for carrying out the program in the event of default by the owner. This may take the form of cash or an irrevocable letter of credit. (Sample attached.)

2. A completed form — "Submission of a Rehabilitation plan", which includes:
   (a) Statistical and operating date required by the Regulation.
   (b) A written description of the operation.
   (c) A written description of the progressive and final rehabilitation program.

   The form has been prepared with specific questions and space for inserting answers which apply to the particular quarry. The items are mostly of a statistical or descriptive nature which are difficult to show on a drawing.

   A review of the operation for conformity with other regulations should be made at this time, i.e.,
   - does the operation conform to municipal land use and zoning by-laws?
   - will noise, dust or waste disposal require licencing by the Clean Environment Commission?
   - will the water table be affected requiring a licence under the *Water Rights Act*?

   It is realized that the estimate of the production and proposed rehabilitation for the next three years will be tentative and may be subject to market fluctuations and other factors outside the control of the aggregate operator.

3. Drawing of the Mining Operation:
   Duplicate drawings are required to illustrate the proposed mining operation and compliance with the Regulation. In the enclosed example, this drawing is called the "Mining Plan".

   The scale of the drawing must be suitable to show the details of the operation. A good working scale is 200 feet to the inch. For a small quarry, the drawing can be prepared by plotting the quarry on the grid as indicated on the attached example. The example also shows how symbols and arrows can be used to show the required information.

   More complex or larger quarries may require surveys and professionally-prepared drawings to show the operation in a meaningful way. Aerial photographs, enlarged to a scale of 200 feet to the inch may be suitable for some quarries.

   Typical cross-sections can be used to provide data not shown otherwise.

   The drawing should include all the applicable information listed on the example drawing which includes: location and outline of the quarry with reference to legal land survey; property boundaries; buffer zones; pertinent installations and natural features such as roads, power lines, streams, etc.; depth, shape and extent of the deposit; location of stripping and stockpiles; forested areas, pasture lands, crop lands, etc.; mining depths and relation of mining to the water table; areas which will be mined below the water table; location of processing equipment, plant or buildings and of settling ponds; location of buildings within 500 feet outside of the property boundary; location of tree screens, berms, fencing, planting vegetation on unworked areas and slopes.

4. Drawing of the Proposed Rehabilitation:
Duplicate drawings (titled Rehabilitation Plan) are required to illustrate rehabilitation as mining progresses and when mining is completed. These drawings may be submitted on the attached blank plans titled "Rehabilitation Plan", or may include any other drawings in accordance with the size and complexity of the mining operation. The drawings should include details of berms, tree screens, vegetation slopes, and proposed afteruse.

The basic objective of rehabilitation is to leave the areas aesthetically pleasing and suitable for productive afteruse. It is realized that some quarries may operate for many years during which time the original conceptual plan may be subjected to many changes as the quarry progresses. However, it is necessary to have a suitable goal to work towards, recognizing that changes are likely to occur and that revised plans may be approved as variations in the quarry operation or adjacent land-use occur.

Through the development of the "Submission of a Rehabilitation Plan" form, the mining drawing and rehabilitation drawing, a comprehensive overview of the total operation will have been made. By this process, it is anticipated that the objectives of the rehabilitation program can be recognized and fulfilled.

Part II — Rehabilitation

The following information is provided for assisting quarry operators in the preparation of their Rehabilitation Plans.

1. Slopes

Of prime importance in any rehabilitation program is the establishment of slopes appropriate for the afteruse of the quarry.

During operation, safety regulations require that slopes not exceed 45 degrees from the horizontal for unconsolidated material. The following table is offered as a guide to slopes that are suitable for various afteruses.

Grade	Slope	Typical Uses
50%	2:1	Vegetated bank — unmowed
30%	3:1	Wildlife Preserve, auto test course, mowed lawn, highrise residential tract, ski slopes, hiking trails.
20%	5:1	Campsites, hunting resort, toboggan slopes.
15%	6½:1	Single family residential — low density, tree farm, golf course, grazing land.
10%	10:1	Picnic areas, intensive campsites, hard surfaced streets, cottage and utility buildings, ramps, driveways, concrete walkways, commercial sites, archery, riding.
8%	12½:1	Seasonal cottages, golf driving range, single family residential (medium density), intensive play areas, zoo, roads.
5%	20:1	Service areas, parking areas, industrial sites, nursery farm, truck farm.

Underwater slopes require special considerations. Safety must be a prime consideration. Slopes above and below water must be such as to enable persons to escape should they accidently fall in. Drop-offs in normal wading depth could be a serious hazard and should be avoided.

Grade	Slope	Typical Underwater Slopes
5%	1:20	Swimming.
15%	6½:1	Stormwater retention lake, cattle dugout.
20-25%	4 to 5:1	Boat launching ramp.

It should be noted that steeper shoreline slopes tend to control aquatic plant growth. Excessive plant growth may cause stagnation, oxygen depletion, mosquito breeding and loss of aesthetics.

2. Vegetation

Tree screens, effectively improve the appearance of the operation and mitigate the impact. If the operation has natural trees, these may provide suitable screening and should be preserved to the extent possible.

Alternatively, on an open pasture setting, an acceptable screen may sometimes be provided by the use of overburden to build berms which can be sloped and seeded.

Screening requirements vary, but must be considered adjacent to roads and residences.

3. Stockpiles

(a) Topsoil and Overburden — locations should be selected to minimize movement of material and to keep topsoil and overburden separate. Since these are normally left for a few years before being used for rehabilitation, they should be sloped at an angle which would permit seeding to prevent wind erosion and improve appearance.

Overburden uses:

a) used as a berm and to control view of mining operation,
b) fill shallow water areas and depressions,
c) as backfill to stabilize slopes.

(b) Product Stockpile — normally angle of repose is adequate. A low profile or tree screening may be indicated when in proximity to residences, public areas or main highways.

(c) Waste or reject material — can be used to advantage in sloping depleted areas.

4. Easements and Buffer Zones

(a) No mining, stripping or stockpiles within 50 feet of property boundary except with agreement of the owner of adjacent property, or upon approval.

(b) All easements and allowances for roads, hydro lines and railways are treated as other property boundaries.

Source: Manitoba Department of Mines, Natural Resources and Environment, 1979.

APPENDIX 11. FEDERAL AND PROVINCIAL APPROACHES TO ENVIRONMENTAL IMPACT ASSESSMENT

	CANADA	NEWFOUNDLAND AND LABRADOR	BRITISH COLUMBIA

BASIS FOR ENVIRONMENTAL IMPACT ASSESSMENT	• *Government Organization Act*, 1970.
	• Cabinet Decision 20/12/73, adjusted 15/2/77
	• **Policy**: established Environmental Assessment and Review Process (EARP). No enforcement in the legal sense.
		• *Environmental Assessment Act*, 1980
		• Purpose of the Act is to facilitate the wise management of Natural Resources and to protect the environment and quality of life of the people of the province.
			• No specific legislation requiring E.I.A. Approximately 45 separate statutes refer to aspects of environmental and social impact. The main statutes include:
			  • *Environmental and Land Use Act*, 1979.
			  • *Land Act*, 1979.
			  • *Water Act*, 1979.
			  • *Pollution Control Act*, 1979.
			  • *Environmental Management Act*, 1980.
			  • *Mines Act*, 1981.
			• **Policy**: Environment, social and economic assessments are required for all major development proposals in the Province.

LEGISLATION/ POLICIES	• *National Energy Board Act*, R.S. 1970. • *Atomic Energy Control Act*, R.S. 1970.		
WHO DETERMINES WHAT IS ASSESSED	• All projects initiated or funded by the federal government or when Federal property is involved. Private projects only if federal assistance involved or federally sponsored. Each federal department or agency involved is responsible for implementing EARP. • Ministry of Environment is responsible for evaluating the performance process. Multi-step process.	• Applies to all public and private sectors. Includes all mineral, petroleum and other resource development projects programs and related activities. Until the requirements of the Act have been met, no provincial department, municipal council, or other local, authority may issue any licence, permit, or approval. No exceptions. • Consumer Affairs and Environment	• Environment and Land Use Committee (ELUC) composed of various departmental ministers. Applies to private and public sectors. • Administration of EIA policy is mainly carried out by the Ministry of Environment through its separate agencies or other lead agencies.

MINISTER AND DEPARTMENTS RESPONSIBLE FOR ENVIRONMENTAL IMPACT ASSESSMENT	• Environment:
	  • Screening and Co-ordinating Committees
	  • Environment Review Board
	  • Environmental Assessment Panels
	• National Energy Board
	• Atomic Energy Control Board.
		• Environmental Assessment Board appointed by Minister to conduct public hearings.
		• Assessment Committee; appointed by Minister to advise on scientific and technical matters.
		  1. Environmental Impact Statement
		  2. Detailed Environmental Assessment
		  3. Environmental Assessment Approval
		• Public involvement is required. All documents are to be måde available to the public.
			• Formal public hearings at discretion of minister.
			• Environment:
			  • ELUC Secretariat (Major Coordinating Agency)
			  • Land Management Branch (Crown Land)
			  • Water Rights Branch (Water Resources)
			  • Pollution Control Branch
			  • Mines and Petroleum Resources; Reclamation Division

		• Proponent is required to conduct a public information exchange program within the proposed development area conforming to procedures approved by the Department as part of terms of reference.	• Three Assessment Levels: 1. Simple cross-agency 2. Small scale cross-agency 3. Large scale multi-stage assessments.
GUIDELINES AND PROCEDURES AVAILABLE FOR ENVIRONMENTAL IMPACT ASSESSMENT	• Revised guide to the Federal Environmental Assessment and Review Process • Screening Guidelines (1978) • Guidelines for Preparing Initial Environmental Evaluations • Oil and Gas Exploration and Production • Ecological land survey guidelines for Environmental Impact Analysis. • Mining and Industrial Developments.* • Guide to licensing of Uranium and Thorium Mine — Mill Facilities. • Environmental Assessment Panels — What They Are — What They Do	• General guidelines for the content of Environmental Impact Assessment. • Guidelines for the Preparation of Terms of Reference for an Environmental Impact Statement for an Industrial Facility.	• Approval Procedures for Land Development • Guidelines for Linear Development • An Evaluation of Environmental Impact Assessment Methodology for Linear Development • Environmental and Social Impact Compensation/Mitigation Guidelines. • Procedures for Obtaining Approval of Metal Mine Development. • Guidelines for Benefit-Cost Analysis. • Guidelines for Coal Development.
WHO CONDUCTS AND PAYS FOR THE ASSESSMENT	Proponent or its consultant prepares E.I.A. • Proponent pays costs.	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.
WHO APPROVES OR REJECTS A PROJECT	• Ministers of the departments involved.	• Minister of Provincial Affairs and Environment.	• Environment and Land Use Committee.
APPEAL PROCEDURE	• To Federal Cabinet.	• Cabinet.	• Provincial Cabinet.
COMMENTS	• The review process is continually being modified and new guidelines issued. • Screening and Coordinating Committees: provide advisory role in the area of environmental assessment and review. • Environmental Review Board: is established in exceptional case by ministers to review a project of great public interest. • Environmental Assessment Panels: review projects which the initiating or sponsoring department considers significant. Separate panel for each project. • Chairman from the Department of Environment.	• Exemptions are allowable at the discretion of the minister where he is of the opinion it is not in the public interest. • No refusals to date for E.I.A. requested by the Department. • All new mines are subject to impact assessments.	• ELUC Secretariat has initiated a common procedures approach to E.I.A. based on those developed for coal, 1976. • Guidelines provide for a multi stage reporting process which is intended to be systematic from general overviews to specific definition of impacts and associated plans: 1. Preliminary Assessment 2. Detailed Assessment 3. Operational Plans of Appropriate Applications 4. Implemenation of continuing monitoring programs • Socio-economic impact analysis and public participation are considered integral.

	SASKATCHEWAN	ALBERTA	ONTARIO
BASIS FOR ENVIRONMENTAL IMPACT ASSESSMENT **LEGISLATION/ POLICIES**	• *Environmental Assessment Act*, 1980	• *Land Surface Conservation and Reclamation Act*, 1973. • No specific legislation requiring E.I.A. Section 8 of the Act allows the initiation of E.I.A. procedures on a discretionary basis. • **Policy:** Ministerial policy under the Act. Any operation or activity resulting in an surface disturbance is subject to an E.I.A. Ministerial order 26176 pursuant to the Dept. of Environment Act delegates the authority contained in Section 8, Land Surface Conservation and Reclamation Act to the Assistant Deputy Minister Environmental Co-ordination Service, Dept. of Environment.	• *Environmental Assessment Act*, 1975: Specific Act promulgated for public sector activities only October, 1976. Extended to municipal projects July, 1980. • *Mining Act*: (for land surface reclamation). • *Environmental Protection Act*.
WHO DETERMINES WHAT IS ASSESSED	• All public or private development projects (1) have a major impact on a specific area; (2) will limit or pre-empt the use of another resource; (3) are or may be of a major public conern; • If the use of provincial resources involved, must take into account environmental, social and economic implications.		• Any significant environmental change that may arise from a major commercial or business activity or proposal, plan or program for a new development. • Section 14 of the Act allows terms and conditions to be placed on project approvals. Ministry favours this approach. Minister of Environment has extremely broad discretionary powers. He can exempt projects, deny appeals, disallow public hearings and restrict information disclosures.
MINISTER AND DEPARTMENTS RESPONSIBLE FOR ENVIRONMENTAL IMPACT ASSESSMENT	• Environment: • Environment • Cabinet may only exempt development from the application of the Act in cases of emergency • The public must be informed of those project proposals requiring environmental impact assessments. All environmental impact statements and technical review comments are provided to the public for comment during a minimum 30-day public review period.	• E.I.A. can be instituted by the Minister or on recommendation of the public elected representatives or provincial agencies. E.I.A. often requested where prior Cabinet approval is required. Where it is not required, usually dealt with through existing legislation and referral systems. • Environment: • Environmental Coordination Service • Land Conservation and Reclamation Council (Responsible for reclamation of all lands) Reclamation plans are received in detail before approval by an Interdepartmental Committee.	• Environment: • Environmental Assessment and Planning. • Environment Assessment Board.

GUIDELINES AND PROCEDURES AVAILABLE FOR ENVIRONMENTAL IMPACT ASSESSMENT	• General Guidelines for the Preparation of an Environmental Impact Statement. • Guidelines for the Submission of a Project Proposal • Mineral Exploration Guidelines.	• Environmental Impact Assessment Guidelines • Environmental Impact Statement Guidelines for Clean Air Act Applications, • Guidelines for Reclamation of Land Affected By a Surface Disturbance, • Guidelines for the Preparation of a Cost/Benefit and Social Impact Assessment, • Guidelines Historical Resources Impact Assessments, 1977. • Requirements for Identification, Analysis and Evaluation of Community Impacts.	• General Guidelines for the Preparation of Environmental Assessments • Guidelines for the Onakawana Development • Environmental Assessment guidelines for specific projects. • Making your case at the Environmental Assessment Board, (D. Paul Emond and Andrew J. Roman, 1980) • Guidebook on the Preparation and Submission of Expert Witnesses Evidence before the Ontario Environmental Assessment Board (Andrew J. Roman *et al.*, 1980)
WHO CONDUCTS AND PAYS FOR THE ASSESSMENT	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.
WHO APPROVES OR REJECTS A PROJECT	• Minister of Environment approves the project with conditions, does not approve or he may appoint a Board of Inquiry to review and prepare recommendations.	• Cabinet Committee.	• Environmental Assessment Board
APPEAL PROCEDURE	• Minister of Environment.	• None.	• None: Only if the Minister of Environment requests its.
COMMENTS	• Early draft guidelines have been applied to major new hydro, coal and uranium developments on an individual basis as they arise: • Social and Community Impact Portions are under the auspices of Departments of Municipal Affairs and Northern Saskatchewan; • Frequent use of public hearings through the Board of Inquiry Process; • All assessments are made public and public hearings held where the public requests or the Minister deems necessary	• The E.I.A. system is designed to integrate with existing licensing, permitting and enforcement agencies. E.I.A. are carried out at the direction of the Dept. of Environment and reviewed through Environmental Coordination Service. • After approval of assessment, permitting and licensing agencies use the E.I.A. to establish environmental protection plans including reclamation. • Environmental Assessments done for site approval and are also a part of a mine reclamation plan approval process.	• Reasons given for delay in implementation of the Act to private sector are : (1) lengthy procedure of drafting regulations; (2) resistance from government departments; (3) desire to give the Environment Assessment board time to gain experience. • Appears that the act will not be extended to the private sector in the near future, although the government has indicated that some private projects may be brought under the Act. • Proposed expansion of uranium mining at Elliot Lake is the only mine project to be subject to an Environmental Impact Assessment.

	NEW BRUNSWICK	QUEBEC	MANITOBA
BASIS FOR ENVIRONMENTAL IMPACT ASSESSMENT **LEGISLATION/ POLICIES**	• *Clean Environment Act*, 1971: the act establishes certain requirements that have to be met by prospective developers. No specific legislation requiring E.I.A. • **Policy:** Environmental Assessment Procedures Policy, October, 1975, Order-in-Council, cabinet agreement sponsored by Environment Department.	• *Environmental Quality Act*, 1972, amended 1974, 1977, 1978, 1979. • **Policy:** Ministerial policy under *Environmental Quality Act*. Generally applies to a large number of private and public projects designated in the Act.	• *Clean Environment Act*, 1972. No specific legislation requiring E.I.A. • *Mines Act*: (for land surface reclamation). • **Policy:** Environmental Assessment and Review Process established in 1975 by Cabinet under Clean Environment Act.
WHO DETERMINES WHAT IS ASSESSED	• All major developments initiated by a provincial department, agency or crown corporation must have an E.I.A. conducted prior to a decision on the implementation of the project. Agreement binding on all public sector activities. Not binding on private sector.	• Regulations under the Act require E.I.A. be done for specific private and public projects involving railroads, power transmission lines, pipelines, gas pipelines, and all mine developments. E.I.A. may be initiated at ministerial, agency, corporate or private citizen levels.	• All projects that significantly affect the environment are subject to a preliminary assessment. Need for a complete E.I.A. determined by EARA subject to the approval of the Minister. The Minister, or Environment Council may recommend any development that has a significant impact on the environment conduct an E.I.A.
MINISTER AND DEPARTMENTS RESPONSIBLE FOR ENVIRONMENTAL IMPACT ASSESSMENT	• Environment: • Environmental Services Branch: responsible for screening projects to determine which ones will be assessed. • Multi-step process: 1. Project screening (pre-assessment) 2. Phase I EA (prior to 'go' decision) 3. Phase II EA (additional detail) 4. Compliance monitoring (after 'go' decision) • Limited public input.	• Environment: • Environmental Protection Services Advisory Council on the Environment. • Quebec Planning Development Bureau Strong emphasis is placed on planning at Regional level. • Multi-step process for large projects: 1. Prepare Environmental Impact Statement 2. Public information and consultation 3. Public hearings. 4. Authorization • No public hearings for minor projects on major projects hearings are held on the request of the public of the the minister	• Consumer and Corporate Affairs and Environment: • Clean Environment Commission. • Environment Council. • Environmental Assessment and Review Agency (EARA). • Mineral Resources Division (land surface reclamation). • Formal hearings at discretion of Clean Environment Commission, but almost certain for new projects.

GUIDELINES AND PROCEDURES AVAILABLE FOR ENVIRONMENTAL IMPACT ASSESSMENT	• Environmental Impact Assessment in New Brunswick. • Individual guidelines for project assessment are made on a case by case basis.	• Règlement général relatif à l'évaluation et l'examen des impacts sur l'environnement • Règlement relatif à la procédure du bureau d'audiences publiques sur l'environnement. • Avis de projet	• Environmental Assessment and Review Process • Guidelines: respecting all environmental impacts of a proposed project. Respecting probable adverse effects which cannot be avoided. Respective alternatives and the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.
WHO CONDUCTS AND PAYS FOR THE ASSESSMENT	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.
WHO APPROVES OR REJECTS A PROJECT	• Minister of Environment.	• Director, Environmental Protection Services.	• Manitoba Cabinet.
APPEAL PROCEDURE	• Provincial Cabinet Committee.	Quebec Municipal Commission.	• None.
COMMENTS	• E.I.A. includes socio-economic impacts as well.	• The Act requires that all new mines or expansions at existing mines are subject to some sort of Environmental Impact Assessment.	• E.I.A. are required for all major development proposals by departments, agencies or crown corporations. • The EARA reviews government projects for E.I.A. and recommends to Cabinet through the Minister whether a project should be allowed to proceed. • Every proponent will appoint a representative to the agency during the review period for any given project.

	PRINCE EDWARD ISLAND	**NOVA SCOTIA**
BASIS FOR ENVIRONMENTAL IMPACT ASSESSMENT **LEGISLATION/ POLICIES**	• *Environment Protection Act*, 1975. • No specific legislation requiring E.I.A. • **Policy:** Executive Council Minute 14/2/73 requiring Environmental Impact Statements.	• *Environmental Protection Act*, 1973, *Water Act*, 1967 No specific legislation requiring E.I.A. • **Policy:** Ministerial policy under the Act requires that all industrial proposals be accompanied by an application for approval. A full Environmental Impact Assessment is usually reserved for large projects. The normal requirement for smaller projects is a less demanding Environmental Design.
WHO DETERMINES WHAT IS ASSESSED	• Any development proposals initiated by a Department or Agency where there are environmental issues relating to air, land and water. • Under the 1975 Act, the minister may also require an E.I.A. report on any matter related to pollution.	• Minister, council or departmental personnel may require an E.I.A. for any development proposal, as part of the permit or licence approval process.
MINISTER AND DEPARTMENTS RESPONSIBLE FOR ENVIRONMENTAL IMPACT ASSESSMENT	• Environment: • Environmental Policy Advisor coordinates all environmental impact assessments.	• Environment: • Environmental Control Council. • Involves a 3-step approval process: 1. Environmental Impact Statement 2. Detailed Environmental Assessment 3. Environmental Approval
GUIDELINES AND PROCEDURES AVAILABLE FOR ENVIRONMENTAL IMPACT ASSESSMENT	• Guidelines for gravel pits and sand mining operations. • Established procedures for undertaking E.I.A.	• Proposed Guidelines for surface mining operations • Proposed Regulation under Environmental Protection Act: Pits and Quarries • Guidelines for Environmental Assessment.

WHO CONDUCTS AND PAYS FOR THE ASSESSMENT	• Proponent or its consultant prepares E.I.A. • Proponent pays costs.	Proponent or its consultant prepares E.I.A. • Proponent pays costs.
WHO APPROVES OR REJECTS A PROJECT	• Minister of Environment.	• Minister of Environment.
APPEAL PROCEDURE	• Cabinet	None.
COMMENTS	• The policy affects the public sector only. However, most private developments have qualified for DREE grants and must meet Federal EARP requirements.	• Consideration is being given to public involvement. All new mines are subject to some form of impact assessment.

Source: Canadian Council of Resource and Environment Ministers, 1977. "Environmental Impact Assessments in Canada", Queen's Printer, Victoria, B.C. and Legislative Acts and Regulations of the provinces pertaining to Environmental Impact Assessment up to 1980. For a more complete up-to-date review see recently published: "Environmental Assessment in Canada — 1982 Guide to Current Practice", Canadian Council of Resource and Environmental Ministers, 1982.

APPENDIX 12: INVENTORY OF RECLAMATION PROJECTS: Federal, Provincial and University Departments and Agencies

The list of projects presented here is not exhasutive, nor was it possible to attempt a systematic review of all those individuals or agencies involved in the extremely wide number of disciplines and subjects associated with reclamation today. It is aimed at providing an indication of the growth and current direction of reclamation activities in Canada.

The compilation of reclamation projects is directed towards Federal, Provincial and University involvement in the field. The study did not attempt to review all private company research, but focused primarily on those projects which were in cooperation with government or university departments and agencies.

The codes used to characterized the individual projects according to Initiating or Funding Agency, Level of Research Involvement and Type of Research Activity are as follows:

Initiating or Funding Agency:

F - Federal Government Department/Agency;
P - Provincial Government Department/Agency;
U - University Department/Research Centre;
X - Private Consulting Company;
C - Company Directed or Staffed Research.

Level of Research Involvement:

1 - Directly Related Research Designed to Reclaim Mining Disturbances combined with Actual Site Reclamation;
2 - Directly Related Research Designed to Reclaim Mining Disturbances;
3 - Indirectly Related Research — Research results that could be applied to reclaim various land disturbances;
4 - Site Reclamation Only.

Type of Research Activity:

Li - Literature Review — bibliographies, reclamation planning;
Lab - Laboratory Based Research;
Gse - Greenhouse Experiments;
Fld - Field Test Trials — biophysical inventories or environmental impact assessment;
Rcl - Actual Site Reclamation.

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY					DURATION	COOPERATIVE AGENCY OR INDUSTRY
				LI	LAB	GSE	FLD	RCL		
	NEWFOUNDLAND									
FC2	Energy, Mines and Resources, Canada CANMET/Pit Slope Project	D. Abott, N.B. Research & Productivity Council	*Pedological Inventory of Mining Wastes. Cooperative Revegation Project.*		X		X		1974-75	1. Iron Ore Co. of Canada. 2. Wabash Mines Ltd.
F 1	Environment Canada Forestry Service	J. Richardson Newfoundland Forest Research Centre, St. John's	*Experimental techniques and species for revegetating gravel pits in Terra Nova, National Park.*		X		X			Parks Canada.
F/C1	Environment Canada Forestry Service	S. S. Sidhu Newfoundland Forest Research Centre	*Revegetation studies and reclamation of Mine tailings at Buchan's Mine, Grand Falls.*		X		X	X	1977	ASARCO Incorp.
	NOVA SCOTIA									
FC2	Energy, Mines and Resources, Canada CANMET/Pit Slope Project	D. Abott, N.B. Research & Productivity Council	*Pedological Inventory of Coal and Gypsum. Mining Wastes in Nova Scotia. Cooperative Revegetation Project.*	X	X		X		1974-77	1. Thorburn Mining Ltd. 2. Cape Breton Development Corporation. 3. Georgia Pacific Corporation. 4. National Gypsum Ltd.
F3	Energy, Mines and Resources	S. B. McCann, Geography Dept. McMaster University	*Survey on the control of dune erosion on Sable Island, Nova Scotia.*				X		1975-76	

C/P1	Cape Breton Development Corporation	G. Boutilier, Sydney R. S. Morton, Truro	*Reclamation of former coal mine sites; Alder Point & Point Aconi.*		X	X	X	1975 + continuous	Nova Scotia Departments of Environment, Agriculture, and Highways.
P 2	Nova Scotia, Department of Environment	Staff, Environmental Assessment	*Environmental Assessment for Land reclamation of Old mining sites.*			X		1976 +	
PF1	Cape Breton Development Corporation	G. Boutilier, Staff	*Reclamation of three coal mine waste dumps at New Waterford.*		X	X	X	1974 +	Nova Scotia Departments of Environment, Agriculture and Highways.
PC 2	Nova Scotia Department of Environment	W. A. Coulter Environment Assessment Branch	Reclamation Planning for proposed Novasco Coal Strip Mine, Point Aconi, N.S.	X			X	1979-85	Cape Breton Development Corporation.
	NEW BRUNSWICK								
F2	Agriculture Canada, Research Branch	A. J. MacLean, Soil Research Institute Ottawa.	*Vegetation trials on acid-pyrite bearing mine tailings: Heath steele, New Brunswick.*		X	X		1974-75	Energy, Mines and Resources, Mines Branch, Montréal Engineering Co. Ltd.
F3	Environment Canada, Environmental Protection Service	D. D. Kristmanson, Chemical Engineering Department, University of New Brunswick	*Pedological Inventory of mining wastes Cooperative Revegetation Project.*		X	X		1974-75	1. Anaconda Canada. Caribou Mine 2. Heath Steele Mines Ltd. 3. N.B. Mining & Smelting Corporation No. 6 and No. 12, Bathurst.

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	 LAB	 GSE	 FLD	 RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
P 2	New Brunswick Department Natural Resources	D. E. Barnett Mineral Resources Branch	*Statutory, reclamation and supply aspects of mineral aggregate production in Canada.*	X					1976-77	Canadian Mines Ministers Conference.
F2	Energy, Mines and Resources CANMET/Pit Slope Project	D. Abbot, N.B. Research and Productivity Council	*Preparation of a bibliography on mine waste revegetation in Canada. Coperative revegetation Project.*	X					1976	
FP2	Environment Canada, Environmental Protection Service, Water Pollution Control Directorate	Montreal Engineering Co. Ltd., Fredericton, N.B.	*Mine Water Quality Program: base metal mine waste management in New Brunswick. Proposed reclamation techniques to control acid mine drainage.*	X	X		X		1972-73	New Brunswick Department of Natural Resources.
PC1	New Brunswick Department of Natural Resources	Forest Service N.B. Research and Productivity Council.	*Reclamation of 4,600 acres of coal strip mined land. Revegetation (reforestation) program.*		X			X	1967-74	N.B. Coal Ltd. Minto Mine Site.
P 1	New Brunswick Department of Natural Resources. Forestry, Fish and Wildlife Branch.	M. J. Nightingale	*Vegetative and site evaluation on surface mined ponds for development of wildlife management practices.*		X		X		1971-72	N.B. Coal Ltd. Minto Mine Site.

P 1	New Brunswick Department Natural Resources Fish and Wildlife Branch.	W. C. Hooper	*Establishment and management of sport fish in abandoned surface mine ponds. Grand Lake, New Brunswick.*		X		X	1971-73	N.B. Coal Ltd. Minto Mine Site.
P 2	New Brunswick Coal Ltd.	D. Abott, New Brunswick Research and Productivity Council.	*Reclamation of coal stripped land at Minto Site.*	X		X		1974 +	N.B., Department of Natural Resources.
	QUEBEC								
F/C2	Agriculture Canada, Research Branch	A. J. MacLean, Soil Research Institute Ottawa.	*Vegetation trials on acid-pyrite bearing mine tailings: Quemont and Waite Amulet mines, Noranda, Québec.*		X	X		1974-75	Quemont Mines Ltd. Noranda Mines Ltd.
FC2	Quebec Asbestos Mining Association Energy, Mines and Resources CANMET/ Pit Slope Project	R. C. Zimmerman T. R. Moore; Geography Department, McGill University.	*Studies on the revegetation of Asbestos Mine Wastes. Cooperative Revegetation Project.*		X	X		1971-77	1. Carey Canadian Mines Ltd. 2. Canadian Johns Manville, Co. Ltd. 3. Lake Asbestos of Québec Ltd. 4. Asbestos Corporation Ltd.
U 2	Université de Montréal	F. Ochmicheon, Department of Landscape Architecture	*Reclamation and stabilisation of steep slopes by uprooted wood cutting.*			X	X	1975-76	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY					DURATION	COOPERATIVE AGENCY OR INDUSTRY
				LI	LAB	GSE	FLD	RCL		
FC2	Energy, Mines and Resources CANMET/ Pit Slope Project	D. Abott, New Brunswick Research and Productivity Council	*Pedological inventory of waste embankments; Open pit iron and titanium Mines. Cooperative Revegetation Project.*		X		X		1974-77	1. Gaspé Copper Mines Ltd. 2. Québec Cartier Mining Co.
FC2	Energy, Mines and Resources; CANMET/ Pit Slope Project Quebec Metal Mining Association	M. Cossette, P. C. Aitcin, Project Coordinator; Centre de technologie de l'Environnement, Université de Sherbrooke.	*Pedologic inventory of mining and milling wastes in specified areas of Québec; Northwest Québec. Cooperative Revegetation Project.*		X		X		1974-77	1. Rio Algom Ltd., Mines de Poirier 2. Louvem Mining Co. Ltd. 3. Mattagami Lake Mines Ltd. 4. Kerr Addison Mines Ltd. Normetal 5. Camflo Mines Ltd. 6. Lamarque Mining Co. Ltd. 7. Sigma Mines, Ltd. 8. East Malartic Mines Ltd.
FC2	Agriculture Canada Research Branch	A. F. MacKenzie, Renewable Resources Department, MacDonald College.	*Effect of pipeline construction on the productivity of soils in Western Québec and Eastern Ontario.*		X		X		1976-77	Trans Canada Pipeline Ltd.
F3	National Research Council of Canada.	E. McKyes, Agricultural Engineering Department, McGill University.	*Damage to soil structure from vehicle traffic.*		X		X		1976-77	

FC2	Energy, Mines and Resources, Canada Centre for Mineral and Energy Technology.	Montréal Engineering Co. Ltd., Montréal, Québec.	*Report on Sulphide Mine Tailings in Rouyn-Noranda. Coperative Revegetation Project.*	X	X		X		1974-75	Falconbridge Copper Ltd., Lake Dufault.
C/U1	Noranda Mines Ltd. Horne Division, Noranda	Staff E. Watkin, Crop. Science Dept., University of Guelph	*Field tests and site reclamation at Horne Mine.*	X	X	X	X	X	1974-79	
F3	National Research Council of Canada	Geo Chem Laboratories Ltd., Laval, Québec	*Microbial Degredation of wastes from Alberta Tar Sands Plants.*		X		X		1979-80	
	ONTARIO									
PC2	Ontario Department of Environment	G. M. Courtin, Biology Department Laurentian University.	*Studies on the utilization of processed organic wastes (sewage and sludge) for reclamation of acid mine tailings.*		X		X		1973-76	International Nickel Co. of Canada Copper Cliff Mine
F 2	Agriculture Canada, Research Branch.	A. J. Maclean, Soil Research Institute.	*Vegetation trials on acid-pyrite bearing mine tailings. Elliot Lake, Ontario.*		X		X		1974-75	Energy Mines and Resource, Mines Branch
FC1	Energy, Mines and Resources Canada, Centre for Mineral and Energy Technology.	*D. R. Murray, Elliot Lake Laboratory.*	*Surface stabilization by vegetation of uranium tailings at Elliot Lake.*		X	X	X	X	1971-80	Rio Algom Ltd. Denison Mines Ltd.
CP1	Rio Algom Mines Ltd.	A. J. Viryurka, Research and Development Department Erocon Ltd.	*Rehabilitation of uranium mine tailings, Elliot Lake.*		X		X	X	1970 + continuous	Ontario Min. of Environment Industrial Waste Branch.

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	 LAB	 GSE	 FLD	 RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
CU1	Falconbridge Nickel Mines Ltd.	Industrial Wastes Control Department. R. Michelutti, A. J. Fedko, M. J. Hulley, P. E. Langford, D. C. Goylor, R. J. Cyr, A. J. Johnston.	*Vegetation stabilization studies on soils and iron-sulphur acid mine tailings at Falconbridge. (Nickel Rim Mine, Hardy Pyrrhotite Stockpile. East Mine Tailings).*		X	X	X	X	1972-78	G. Courtin, I. Spiers Laurentian University, and Erocon Ltd.
P 3	Ontario Hydro, Research Division	F. S. Spencer Biologist.	*Study into the effects of thermal stress on growth of plant cover on electric power underground transmission lines.*		X		X		1974-75	
PC2	Ontario Ministry of Environment Sudbury Region and Regional Municipality of Sudbury.	E. K. Winterhalder, Biology Department, Laurentian University. I. McAuley, S. McGrinn, L. Michelutti, S. Rapundalo Falconbridge Nickel Mines.	*Reclamation studies using composted city refuse as an aide in revegetating Industrial barrens.*		X		X		1976 +	Coniston Mines Falconbridge Nickel Mines Ltd. INCO.
P 1	Ontario Hydro, Research Division.	E. Gillespie	*Revegetation studies for hydro transmission right-of-ways.*				X		continuous	
CU1	Noranda Mines Ltd. Geco Division. Manitouwadge.	Mine staff. E. Watkin, Crop Science Department. University of Guelph	*Studies to establish vegetation on high sulphide mine tailings.*		X	X	X	X	1974-79	

FC3	Natural Sciences and Engineering Research Council of Canada	H. Chabwela University of Guelph	*Ph.D. Thesis, Resource Management Issues related to open strip mining. Effects of aggregate extraction on Wildlife Habitats. TCG Materials, Aberfolye property.*	X		X	1981-82	TCG Materials Ltd. Brantford Canadian Commonwealth Scholarship Committees
F2	Parks Canada Environment Canada	J. Douglas Terrain Development Section, Municipal Services Indian Affairs and Northern Development	*Preparation of site Rehabilitation Manual for use in National Parks*	X			1980-81	Indian Affairs and Northern Development
F2	Environment Canada Environmental Protection Service Nuclear Programs Division	M. Kalin Inst. Environmental Studies, University of Toronto	*Investigation of abandoned uranium mill tailings at Uranium City, Saskatchewan; Elliot Lake and Bancroft, Ontario, to determine movement of toxic species into plants in these areas.*	X	X	X	1980-81	
FC2	Natural Sciences and Engineering Research Council of Canada	M. I. Heagy, P. B. Cavers, Dept. Plant Sciences University of Western Ontario	*Natural Revegetation of abandoned gravel pit slopes Southwestern, Ontario*			X	1978-79	ICG Materials Ltd. Standard Aggregates Ltd.
F2	Energy, Mines and Resources, Canada CANMET/Pit Slope Project	P. C. Aitcin. Project co-ordinator. Centre de technologie de l'Environnement. Université de Sherbrooke.	*Pedologic Inventory of Mining and Milling Wastes in specified areas of north eastern Ontario. Kirkland Lake Cooperative Revegetation Project.*		X	X	1974-77	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	LAB	GSE	FLD	RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
F3	Energy, Mines and Resources, Canada. Centre for Mineral and Energy Technology.	A. A. De-Gast, Mining Engineering, Queen's University.	*Mine Backfill Stabilization.*	*X*					*1972-73*	
F3	*National Research Council of Canada.*	*T. C. Hutchinson, Botany Department. University of Toronto.*	*Occurrence and distribution of metallic pollutants on the air, soil and water around Sudbury and metropolitan Toronto. Toxicity to vegetation.*		X		X		1972-77	
F3	National Research Council of Canada.	D. W. Smith, Botany Department. University of Guelph.	*Studies of the effects of disturbance factors in natural ecosystems.*		X		X		1972-76	
FC2	Energy, Mines Resources, Canada CANMET/Pit Slope Project	Montréal Engineering Co. Ltd., Montréal, Québec.	*Report on Sulphide Mine Tailings in Timmins and Sudbury Area. Cooperative Revegetation Project.*	X	X		X		1974-75	Texasgulf Canada, Kidd Creek. Parmour Porcupine, Schumacher Mine. Dome Mines Ltd. Falconbridge Nickel Ltd., Hardy Onaping and Falconbridge Mines. Inco, Coppercliff
P2	Ontario Ministry of Natural Resources.	Forest Management Branch, Division of Forest.	*Preparation of a guide book on vegetation for the rehabilitation of pits and quarries.*	X					1974-75	Advisory Committee, Chairman C. J. Heeney.

FU3	Environment Canada, Environmental Management Services, Canada Centre for Inland Waters.	Acres Consulting Services Ltd. Niagara Falls	*Study of the role of vegetation in stabilizing the Lower Great Lakes Canadian Shoreline.*		X	X		1975-76	Botany Department. University of Guelph.
FC2	Energy, Mines and Resources, Canada. Centre for Mineral and Energy Technology.	Rio Algom Ltd. Elliot Lake	*Examination of the effect of surface treatment of uranium tailings areas on quantity and quality of effluent seepage.*	X	X	X	X	1971-85	D. Murray. CANMET-LAB. Elliot Lake.
F3	Energy, Mines and Resources, Canada. Centre for Mineral and Energy Technology.	Acres Consulting Services Ltd. Burlington, Ont.	*Study of the use of tailings as back fill in uranium mines.*				X	1977-78	
F3	Environment Canada. Environmental Protection Service.	Hydrology Consultants Ltd. Mississauga, Ont. Gartner Lee Associates Ltd. Willowdale, Ont.	*Identification of policy options regarding the discharge of wastes on land.*	X				1977	
F3	Environment Canada. Environmental Protection Service.	Canadian Environmental Law Research Foundation Toronto, Ontario.	*Update and integration of the Pollution from Land Use Activities Reference Group Program: Legislative Review.*	X				1977	
F2	Agriculture Canada. Research Branch. Energy Mines and Resources, Mining Research Centre.	A. J. Maclean. Soil. Research Institute. D. Murray, CANMET Elliot Lake Laboratory.	*Physical and chemical analysis of mine tailings for revegetation purposes.*		X	X		1972-74	Rio Algom Mines.

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	LAB	GSE	FLD	RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
PF1	Canada Manpower. Regional Municipality of Sudbury.	Sudbury Vegetation Enhancement Committee. Laurentian University, Biology Dept.	*Revegetation of denuded and contaminated soils with trees and shrubs. Soil sampling, species tolerance and collection of native species seeds.*		X		X	X	1978-83	Ontario Ministry of Natural Resources, INCO, Falconbridge, Ministry of Environment.
P 1	Ontario, Ministry of Natural Resources Forestry Resources Branch.	J. J. Negusanti, Sudbury.	*Sudbury area revegetation program. Tree planting and development of tolerant plant species.*		X		X	X	1973-78	
P 2	Ontario Ministry of Natural Resources and Ministry of Transport & Communications.	Mines Branch, Industrial Minerals Section.	*Development of a plan for the extraction and rehabilitation of gravel at the Puslinch Crown Resource Management Area.*	X					1977	
P2	Ontario Ministry of Natural Resources; Mines Branch, Industrial Minerals Section.	A. G. McLellan, C. R. Bryant Geography Dept. University of Waterloo.	*Effective planning in the Aggregate Industry Reclamation Planning. Inventory of disturbed land (pits and quarries) in Waterloo and South Wellington Counties.*	X			X		1973	
FC2	Environment Canada. Water Pollution Control Directorate.	W. B. Blakeman, Geography Dept., Carleton University (M.A. Thesis)	*Investigation of Volunteer Vegetation on Mine tailings deposits in Ontario and Québec. Introduction of selected species on tailings.*	X	X		X		1974-76	Hilton Mines Ltd.

P2	Ontario Ministry of Natural Resources. Industrial Minerals Section. Regional Municipality of Waterloo.	A. G. McLellan, Geography Dept. University of Waterloo.	*Develop a methodology for assessing extent of abandoned pits and quarries; how to select a post-mining land use and methods of reclamation.*	X		X	1976-77
P2	*Ontario Ministry of Natural Resources. Industrial Minerals Section.*	*A. G. McLellan, Geography Dept. University of Waterloo.*	*To determine a methodology for selecting abandoned pits and quarries for reclamation by the Ministry of Natural Resources.*	X		X	1977-78
P2	Ontario Ministry of Natural Resources. Industrial Minerals Section.	B. Coates, School of Landscape Architecture, University of Guelph.	*Analysis of reclamation work on pits and quarries in 5 counties & regions of S. Ontario since 1971. Determine effectiveness of the 1971 Pits & Quarries Act.*	X		X	1977-78
P2	Ontario Ministry of Natural Resources. Industrial Minerals Section.	Sara Lowe, Arboretum, University of Guelph.	*Evaluation of native plants and shrubs of Ontario for reclamation purposes in abandoned pits and quarries.*	X		X	1976-79
P2	Ontario Ministry of Natural Resources. Industrial Minerals Section.	E. E. MacIntosh, Land Resource Research Centre, University of Guelph.	*Development of reclamation methods to reclaim abandoned pits and quarries for agricultural purposes.*	X	X	X	1978-79

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	ACTIVITY LAB	ACTIVITY GSE	ACTIVITY FLD	ACTIVITY RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
P2	Ontario Environment Pollution Control Branch.	J. Hawley, E. Sheridon. Mining and Metallurgical Section.	*Inventory of all abandoned and inactive mining properties in Ontario.*	X			X		1977-78	Ontario Provincial Lottery Funds.
P2	Ontario Environment. Pollution Control Branch.	E. Sheridon, Mining and Metallurgical Section. T. Bales, Soil Science Dept. University of Guelph.	*Vegetational, physical and chemical analysis of 110 mine tailings sites.*		X		X		1977-78	Ontario Provincial Lottery Funds. Independent Consulting Lab.
CP1	International Nickel Co. of Canada.	T. Peters, Agricultural Division Copper Cliff.	*Use of reclaimed lands for Wildlife Management Area.*	X			X	X	1976 +	Ontario Ministry of Natural Resources.
FC2	Energy, Mines and Resources. CANMET/ Pit Slope Project	Montreal Engineering Co. Ltd.	*Pedological Inventory of mine wastes Cooperative Revegetation Program.*		X		X		1973-74	1. Dome Mines Ltd., S. Porcupine. 2. Parmour Porcupine Mines Ltd. 3. Texasgulf Canada Ltd., Kidd Creek Mine. 4. Falconbridge Nickel Mines Ltd.
P 2	Ontario Ministry of Environment	W. D. McIlveen, D. Balsillie Technical Support Section	*Physical and chemical studies on soils and mine tailings in Cobalt area to determine limiting factors to reclamation.*		X				1976-78	

F 3	National Research Council of Canada	G. K. Rutherford, Geography Dept. Queen's University	*Sulphur and heavy metal content of soils affected by smelter operations at Coniston.*		X	X		1977-78	
U 2	University of Guelph	K. J. Loebel, E. G. Beauchamp. Land Resource Research Centre S. B. Lowe, Aboretum	*Revegetation trials on disturbed dump subsoils amended by composed sludge/tree-leaf mixture.*		X	X		1977-78	
FC1	Energy, Mines and Resources, Canada. Canada Centre for Mineral & Energy Technology. Denison Mines Ltd.	D. Murray, Mining Research Lab., Elliot Lake R. Webber — Metallurgist and E. Larocque — Process Engineer.	*Reclamation of Lower Williams Lake Tailings Area of Denison Mines Ltd.*		X	X		1976-78	Denison Mines Ltd.
CP4	Dufferin Aggregates, St. Lawrence Cement	Staff/contract	*Environmental Planning and rehabilitation of Milton Quarry, Milton. (Niagara Escarpment)*				X	1975-80	Niagara Escarpment Commission.
P1	Ministry of Natural Resources. Ministry of Transport & Communications	W. O. Scott, J. J. Armstrong Staff	*Phased extraction and rehabilitation of the Puslinch Crown Resources area — Cambridge*		X	X	X	1977+	
CP1	Aggregate Producers Association of Canada. Metropolitan Toronto & Region Conservation Authority	Staff/consulting	*Cooperative land rehabilitation project. Glen Major Site, Uxbridge Twp.*	X		X	X	1977+	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	 LAB	 GSE	 FLD	 RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
CP1	Standard Aggregates, Standard Industries Ltd.	Staff/consulting J. S. Stratton	*Reclaiming mined aggregate lands at Snuffville, Paris, London and Hagerville sites, S. Ontario.*	X			X	X	1976	Ministry of Natural Resources. Forestry Service. University of Guelph.
UC 1	Laurentian University	A. C. Spires Biology Dept.	*Studies on the use of overburden soils to facilitate vegetative growth on high sulphide tailings at Nickel Rim Mine.*		X		X	X	1974-75	Falconbridge Nickel Mines Ltd.
UC 1	Laurentian University	R. B. Bell, J. Pos, R. J. Lyon	*Experimental revegetation test plots using composted lumber mill wastes and chicken manure at Coniston.*		X		X		1973	
PU 1	Technical Tree Planning Committee, Regional Municipality of Sudbury	E. K. Winterhalder P. J. Reynolds B. H. Kett, Biology Dept., Laurentian University	*Revegetation studies on denuded and contaminated soils in the Sudbury Region.*		X		X	X	1974-75	Laurentian University
P4	Ontario Ministry of Housing Project Evaluation Branch	J. E. Hanna Hough, Stansbury, Michalski Ltd. Rexdale, Ont.	*Reclamation of Townsend Quarry Site*	X				X	1977-78	

FC3	Land Resource Research Institute, Agriculture Canada	T. Presant, Guelph, A. McLean and J. Cully, Ottawa Land Resource Research Institute, Agriculture Canada.	*Effect of pipelines on soil properties and methods to minimize their impact on agricultural land.*	X	X	1975 +	Interprovincial Pipelines Ltd.
PC 3	Ontario Hydro	M. L. Della Rossa Natural Resources Development Section.	*Reclamation by hydraulic seeding of large soil disposal area at Darlington Nuclear Generating Station.*	X	X	1979-81	Seeding Contractors
P1	Ontario Ministry of Transportation and Communications	H. C. Spence Landscape Planning and Operations.	*Evaluation of hydraulic mulches*	X	X	1975-80	
CU1	Steep Rock Iron Mines Ltd. Atikokan	P. Capper Metallurgical Department.	*Revegetation of Iron Ore Tailings*	X	X	1978-80	M. Savinsky, Lakehead University.
UC1	Lakehead University, Thunder Bay	M. Savinsky Forestry Department	*Growth and nutrient uptake of poplar cultivars (Populas SPP) on amended iron tailings, Steep Rock Mine, Atikokan*	X	X	1978-79	Steep Rock Mines Ltd.
UC1	Lakehead University, Thunder Bay	G. Zebruck; D. J. Reindand; R. J. Day; J. G. Cowman Forestry Department	*The use of trees and plants to reclaim and stabilize taconite tailings at Griffith Mine, Red Lake*	X	X	1973-75	Pickands, Mather and Co.

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	 LAB	 GSE	 FLD	 RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
U 2	University of Guelph	S. B. Lowe, Arboretum	*Test plots and demonstration collection of plants for materials (woody plants) and methods for pits, quarries road sides, Southern Ontario*	X			X		1976-79	
P2	Ministry of Natural Resources, Industrial Minerals Section	S. B. Lowe Arboretum University of Guelph	*Preparation of a reclamation guide for use by operators in the aggregate industry in Southern Ontario.*	X			X		1976-79	
U 2	Laurentian University	G. M. Courtin Biology	*Autecology of Tree Species by the Industrial Barrens of the Sudbury Basin.*				X		1979-81	
FU2	Natural Sciences and Engineering Research Council of Canada	G. K. Rutherford Geography Department Queen's University	*Examination of soil chemical criteria controlling biological succession on tailings and mine disturbed lands at Sudbury and Coniston.*		X	X	X		1979-81	INCO.
FC1	Energy, Mines and Resources Canada Centre for Mineral and Energy Technology	Erocon Ltd. Timmins, Ont.	*Revegetation trials of uranium trill tailings at Elliot Lake*		X		X		1979-80	Rio Algom Ltd. Denison Mines.
P 2	Ministry of Natural Resources. Forest Resources Centre	J. A. Stocking Lands and Minerals Section	*Demonstration and study centre for Gravel Pit Rehabilitation.*					X	1979 +	

F2	National Research Council of Canada	R. M. Cox T. C. Hutchinson Institute for Environmental Studies, University of Toronto	*Adaptive tolerance of various native plant species and their application to revegetation of metal contaminated sites at Sudbury.*		X	X		1976-80	
FC2	Environment Canada Atomic Energy Board of Canada	Waste Water Centre. Environmental Protection Service. CANMET, Elliot Lake	*Fresh tailings, chemical/biological stabilization tests, Quirke Mine, Elliot Lake*	X		X		1976 +	Rio Algom, Denison Mines, Eldorado Nuclear Ltd., Madawaska Mines Gulf Minerals.
	MANITOBA								
FC2	Energy, Mines and Resources, Canada. CANMET/Pit Slope Project	J. W. Gadsby; Piteau, Gadsby Macleod Ltd. N. Vancouver. E. A. Paul, University of Saskatchewan. R. Arnold, Saskatchewan Research Council. A. Black, University of British Columbia.	*Studies of sulphide tailings at a Base Metal Mine in Flin Flon; Cooperative Revegetation Program.*		X	X		1975-76	Hudson Bay Mining and Smelting Co. Ltd., Flin Flon, Ogrami, D.G. W. W. Fraser.
P1	Manitoba, Department Mines, Resources and Environmental Management	Mining Engineering and Inspection Branch, Mineral Resources Division.	*Reclamation pilot project at two former Gold Mines.*		X	X	X	1976 +	San Antonio Gold Mines Ltd.
CU1	Sherritt Gordon Mines Lynn Lake	Environmental Control Department Crop Science Department. University of Guelph.	*Revegetation trials on mine tailings. Rutton, Fox, Early Mines*	X	X	X		1979-80	

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	SASKATCHEWAN									
P 2	Saskatchewan, Department of Environment	H. T. Epp, Policy, Planning and Research Branch	*Preparation of an annotated bibliography and review of the literature on Strip Mine Reclamation and related activities in Saskatchewan.*	X					1976-77	
P2	Saskatchewan, Department of Mineral Resources	J. E. Jonescu, Geography Dept., University of Saskatchewan, Saskatoon	*PhD. Thesis: Studies on natural vegetation and environmental aspects of strip mined land in the lignite coal fields of southwestern Saskatchewan. Native species revegetation.*	X	X		X		1971-74	
P 1	Saskatchewan, Department of Tourism and Renewable Resources	W. Flavelle H. Kagis, Forestry Branch Prince Albert	*Experimental reforestation on Estevan coal spoil banks, Saskatchewan*		*X*		*X*	*X*	*1963-72*	*Saskatchewan Power Corporation*
F 3	*Canada Agriculture, Research Branch*	*A. K. Ballantyne, Saskatchewan Institute of Pedology, Saskatoon*	*Studies into the creation of saline soils due to wind erosion.*		X		X		1976-77	
F2	Saskatchewan, Department of Environmental Policy, Planning and Research Branch	C. Fitzgibbon, Geography Dept. University of Saskatchewan, Saskatoon	*Studies on erosion of strip-mined spoils around Estevan. Saskatchewan revegetation problems.*		X		X		1974-75	

F2	Energy, Mines and Resources, Canada. CANMET/Pit Slope Project	D. W. Anderson, Saskatchewan Institute Pedology; R. E. Redmann, Dept. Plant Ecology. University of Saskatchewan. M. E. Jonesau, Canadian Plains Research Centre, University of Regina.	*A soil, vegetation and microclimate inventory of strip-mine wastes of the Estevan Area, Saskatchewan. Cooperative Revegetation Program.*		X	X		1974-75	
FC1	Agriculture Canada	D. R. Cram, G. Howe. Indian Head Nursery	*Test planting trees and shrubs on coal mine wastes at Estevan.*		X	X	X	1974 + continuous	Saskatchewan Power Corp. J. McElgumm, Canada Agriculture, Swift Current Station.
PU1	Saskatchewan Power Corporation	A. Klesse, Reclamation Engineer	*Develment of Reclamation Plan for New Poplar River Power Plant. Initiation of test plot studies.*	X	X	X		1976 + continuous	D. Anderson, Saskatchewan Institute of Pedology, Saskatoon. E. Jonescu, Canadian Plains Research Centre, Regina.
P 4	Saskatchewan, Department of Environment	R. E. Watson Land Protection Branch	*Surface rehabilitation of sand and gravel excavations throughout Saskatchewan*	X			X	1977 +	
U 2	University of Saskatchewan	D. W. Anderson Saskatchewan Institute of Pedology	*Characterizing overburden for reclamation planning at Cornach, Saskatchewan*	X		X		1979	

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	ALBERTA									
P 2	Alberta Environment. Environmental Protection Services	Earth Sciences and Licencing Division, Lethbridge	*Problems of salinity in exposed subsurface materials at Bow City.*		X		X		1976-81	
P 2	Alberta Environment. Environmental Protection Services	Earth Sciences and Licencing Division, Lethbridge	*Nitrogen mineralization and nitrification potentials of selected strip mine disturbed soils at Bow City.*		X		X		1977-78	
P 2	Alberta Environment. Environmental Protection Services	Earth Sciences and Licencing Division, Lethbridge	*Reclamation trials on saline and sodic mine spoils*		X		X		1976-77	
P 2	Alberta Environment. Environmental Protection Services	Earth Sciences and Licencing Division, Lethbridge	*Hydrologic effects of coal strip mining in Whitewood Mine Area. Lake Wabamum.*		X		X		1977-78	
P2	Alberta Environment, Land Conservation and Reclamation Division	G. R. Shelly and Associates	*Villeneuve Gravel Study Reclamation Planning.*	X					1976-77	
P3	Alberta Environment, Land Conservation and Reclamation Division	Stone and Webster Ltd.	*Waste Coal Utilization Study.*	X					1976-78	
P3	Alberta Environment, Land Conservation and Reclamation Division	Techman Ltd./ Rheinbraun	*Materials Handling Study of Oil Sands Operation.*	X					1977-78	

P2	Alberta Environment, Land Conservation and Reclamation Division	J. Campbell, Alberta Research Council	*Environmental variability of coal mining sites in the mountain Region of Alberta.*			X	1976-77
P3	Alberta Environment, Environmental Protection Services	Dr. Ebel, University of Lethbridge	*Socio-economic aspects of surface mining for coal; an international comparison.*	X			1976-78
P2	Alberta Environment	Environmental Conservation Authority	*Translation of German text 'Handbook of Landscape care and Nature Protection'.*	X			1976
P3	Alberta Energy and Natural Resources, Alberta Forest Service	D. J. Pluth, Soil Science Dept., University of Alberta	*Erodibility potential for soil mapping units.*	X		X	1977-78
P2	Alberta Energy and Natural Resources	Alberta Forest Service	*Legume, tree and shrub seeding trials; direct seeding trials for reclamation purposes.*			X	1976-78
P2	Alberta Energy and Natural Resources	H. G. Stephenson, Mining Consultants Ltd.	*Survey of materials for reclamation*	X		X	1976
P2	Alberta Environment, Land Conservation and Reclamation Division	Pedology Consultants	*Soil Survey Forestburg strip mine Comparison of Three Hill, Bow City and Forestburg Mine Sites*		X	X	1976

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P2	Alberta Environment, Land Conservation and Reclamation Division	H. G. Stephenson, Mining Consultants Ltd.	*Reclamation of abandoned Surface coal mines; Planning and engineering at Walker and Canmore Creek*	X			X		1976	
P2	Alberta Environment, Land Conservation and Reclamation Division	Western Canada Erosion Control Ltd.	*Survey Reclamation activities*	X					1976-77	
P2	Alberta Environment, Land Conservation and Reclamation Division	Western Canada Erosion Control Ltd.	*Halkirk vegetation check plots.*				X		1976	
P2	Alberta Environment, Land Conservation and Reclamation Division	County of Flagstaff	*Forestburg Revegetation Plots.*		X		X		1976-80	Alberta Agriculture
P2	Alberta Environment, Environmental Protection Service	Earth Sciences and Licencing Division	*Blairmore Slack Coal mine wastes revegetation trials.*		X		X		1973-78	
P1	Alberta Energy and Natural Resources	J. Selner, P. King D. Hidelbrandt Reforestation and Reclamation Branch	*Tent Mountain Reclamation Field Trials*		X		X		1976-79	Alberta Environment Environmental Protection Service.
P3	Alberta Environment, Research Secretariat	Bayrock and Reimchen	*Surficial ecology and erosion potential of the Eastern Slopes of the Rocky Mountains and Foothills.*	X			X		1976-77	

P4	Alberta Environment, Land Conservation and Reclamation Division	Operation Planning Branch	*Purchase and reclamation of abandoned and hazardous coal mine shafts at Crowsnest Pass, and Champion.*	X	1977-78	Environmental Coordination Services Funding
P4	Alberta Environment, Operational Planning Branch	Local Municipality, Land Conservation and Reclamation Division	*Reclamation of abandoned coal strip mines, tipple sites, and hazardous underground shafts at:* *1. Vulcan and Canmore, reclaimed for agricultural purposes* *2. Sturgeon and Hillcrest; for parks and recreation uses.*	X	1977-78	Environmental Coordination Services Funding
P4	Alberta Environment, Land Conservation and Reclamation Division, Energy Conservation Resources Board	Operational Planning Branch	*Reclamation of abandoned coal mine wastes at Blairmore and Bellevue.*	X	1977-78	Environmental Coordination Services Funding Alberta Lands and Forests
P4	Alberta Environment, Land Conservation and Reclamation Division	Operational Planning Branch	*Reclamation of abandoned coal mine pits. Rundle Mountain, Canmore Creek and Walker strip mines.*	X	1976-78	Environmental Coordination Services Funding
P4	Alberta Environment; Operational Planning Branch	Local Municipality; Land Conservation and Reclamation Division	*Reclamation of derelict lands, gravel pits, old industrial sites at:* *- Black Diamond, Lethbridge, Oyen and Redcliff to parks, recreational and sporting grounds.*	X	1977-78	Environmental Coordination Services Funding

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				LI	LAB	GSE	FLD	RCL		
	Alberta Environment; Operational Planning Branch	Local Municipality; Land Conservation and Reclamation Division	*Reclamation of abandoned coal strip mines and hazardous underground shaft sites at:*							Environmental Coordination Services Funding
P1		Alberta Agriculture G. Werner, District Agrologist	*1. Forestburg: Co. of Flagstaff for agriculture purposes.*		X		X	X	1975-80	
P1			*2. Cardiff and Grassey Lake.*				X	X	1975-78	
P2	Alberta Environment Conservation Authority	F. F. Slaney and Co. Ltd., Vancouver	*Study of the environmental impact of surface coal mining operations in Alberta.*	X					1971	
P2	Alberta Energy and Natural Resources	Land Use Branch	*Reclamation for afforestation purposes by suitable native and introduced tree and shrub species.*					X	1974-80	
P4	Alberta Environment Operational Planning Branch	Local Municipality and Land Conservation and Reclamation Division	*1. Reclamation of abandoned coal mine at Three Hills.*					X	1974-76	Environmental Coordination Services Funding
P4	As above	As above	*2. Reclamation of abandoned coal mine at Black Nugget for recreation use.*					X	1974-76	As above.
P4	As above	As above	*3. Training reclamation sites at Bow City Coal mine.*					X	1974-76	As above.

P3	Alberta Environment, Environmental Research Trust	M. Dudas, Soil Science Dept., University of Alberta	*Heavy Metals and other elements in fly ash and their behaviour and influence in fly ash amended soil materials.*	X	X		1977-78
P2	Alberta Energy and Natural Resources, Forest Development Research Trust	G. H. LaRoi, Botany Dept., University of Alberta	*Natural Revegetation on Coal Mined Land.*	X	X		1975-80
P3	Alberta Energy and Natural Resources, Forestry Trust	G. H. LaRoi, Botany Dept., University of Alberta	*An ecological study of flora and vegetation on fire lookout tower sites and their access roads in the Alberta Foothills and Rocky Mountains.*	X	X		1977-78
P1	Alberta Agriculture, Agriculture Research Trust	Plant Industry Lab	*Revegetation of disturbed agricultural lands at Bow City.*		X	X	1977-78
P2	Alberta Agriculture, Agriculture Research Trust	Plant Industry Lab	*Adaptability of species and varieties for revegetation of disturbed agricultural land.*	X	X		1977-78
FP3	Environment Canada - Alberta Environment; Alberta Oil Sands Environmental Research Program	S. Malinotra, Northern Forest Research Centre, Canadian Forestry Services, Edmonton	*Determine effects of SO_2 emissions on vegetation and soils. Identify vegetative species with high resistance qualities.*	X	X		1975-80

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PF2	As above	J. D. Lindsay, Soils Division, Research Council of Alberta, Alberta Institute of Pedology.	*Characterization and utilization of pests as a reclamation material in tar sands.*		X		X		1975-80	
PF2	As above	M. P. K. Nyborg, M. Dudas, F. Cook, W. B. McGill, Soil Science Dept., University of Alberta.	*Soil research related to revegetation of oil sands. Methods of improving damaged soils.*		X		X		1974-80	Alberta Energy and Natural Resources
FC2	Energy, Mines and Resources, Canada. CANMET/Pit Slope Project	R. M. Hardy and Associates Ltd., Calgary, Alberta	*Soil and vegetation inventory of Coal Mining Wastes in the Rocky Mountain Region of Alberta and British Columbia. Co-operative Revegetation programs.*		X		X		1975-76	Kaiser Resources Ltd. McIntyre-Porcupine Mines Ltd., Granby Mining Co. Ltd.
PF2	Environment Canada – Alberta Environment, Alberta Oil Sands Environmental Research Program	Vaartnou and Sons Enterprises Ltd., Edmonton	*Controlled environmental tests of species suitable for revegetation (Native and Introduced). 44 sites across Alberta. Technology of native seed production and handling.*		X	X	X		1974-80	Alberta Energy and Natural Resources; Land Use Coordination Branch.
PF3	Same as above.	D. Whitehead, Botany Dept., University of Alberta	*Long term management prediction of dyke erosion. Dyke management program.*		X		X		1974-78	

PF2	Same as above.	J. M. Mayo, Botany Dept., University of Alberta	*Long term prediction of vegetation performance. Dyke management program.*		X		X		1974-78	
PF2	Same as above.	L. C. Bliss, Botany Dept., University of Alberta	*Oil sands revegetation studies. Northern Development Research.*	X	X	X	X		1974-78	
PF2	Alberta Environment, Reclamation Research Co-ordinating Committee	H. P. Sims, Research Secretariat. L. Brace, Northern Forest Res. Centre.	*A survey of reclamation activities in the province of Alberta.*	X					1976-77	Environment Canada Canadian Forestry Service.
P 2	Alberta Environment, Alberta Lands and Forests	H. F. Regier, Lethbridge	*Revegetation test plots for reclamation of coal mine spoils at Blairmore.*		X	X	X		1972-73	Scurry Rainbow Oils Ltd.
CU2	Syncrude Canada Ltd.	M. J. Rowell, W. B. McGill, S. Takyi, Soil Science Dept., University of Alberta; H. Vaartnou, Alberta Dept. of Agriculture	*Research and test plots for reclamation of surface mined areas. Tar sands Ft. McMurray.*		X	X	X		1969-75	
P1	Alberta Environment	Western Canada Erosion Control Ltd.	*Slave Lake Sands Dunes Revegetation.*	X				X	1973-74	
P1	Alberta Environment	Western Canada Erosion Control Ltd.	*Cardinal River Coal Revegetation Study. Field Trials and Reclamation.*	X				X	1971 +	

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				LI	LAB	GSE	FLD	RCL		
F2	Dept. Indian Affairs & Northern Development; Parks Canada	Intera Environmental Consultants Ltd.	*Cameron Lake Campground. Assessing recreational impact; recommendations for reclamation and restoration.*	X				X	1973	
F 2	Energy, Mines and Resources Geological Survey of Canada	Dr. J. Harrison, Terrain Sciences Division	*Crowsnest – Elk Valley: Environmental Geology: Mountain Coal Mining. To investigate the active natural processes affecting coal spoil and the relationship between these processes and reclamation.*		X		X		1972-76	
P 2	Alberta Recreation, Parks and Wildlife	Provincial Parks Division	*Species suitability for sand dune reclamation at Lesser Slave Lake.*				X		1976 +	
P 2	Alberta Environment, Operational Planning Branch	Earth Sciences & Licencing Division,	*– Blairmore Slack Coal. Revegetation studies.*	X	X	X	X		1973 +	Environmental Coordination Service Funding.
P 2		Lethbridge	*– Three Hills Reclamation Project.*	X	X	X	X		1974-75	
PC2	Alberta Environment, Earth Sciences and Licencing Division	D. McCoy, Technical Development Branch	*– Tent Mountain Reclamation Experiment on #2 Pit, North Waste Rock dump, Using Blairmore Sewage Sludge.*	X	X	X	X		1974-79	Coleman Colleries Ltd.

FP4	Agriculture Canada Research Branch	Lethbridge Research Station	*Grassy Lake Mine Reclamation.*	X				X	1975-78	Alberta Energy and Natural Resources.
FP2	Fish & Wildlife Service, Environment Canada, Fish and Wildlife Division, Alberta	Prof. D. Jaques, Botanist. Environmental Sciences Centre. Univ. of Calgary	*The capabilities of High-Flight aerial photography and land-sat multispectral magery for monitoring coal reclamation activity.*		X		X		1976-77	AMOCO Petroleum Inc.
C/P 2	Calgary Power Ltd., Calgary Environmental Planning Division	Alberta Agriculture - Soil Division. District Agriculturalist. Saskatchewan soil testing lab. Saskatoon. McAllister Environmental Services	*Agricultural potential of reclaimed land, at Whitewood Mine Site, Wabamun Lake, Alta.*		X		X	X	1971 + continuous	
P2	Land Conservation and Reclamation Division. Alberta Environment	Techman Ltd., Calgary	*Selecting materials handling capability of Dragline at Plains Strip Mines. Feasibility of conserving topsoil and subsoil in agricultural land likely to be affected by mining. Reclamation Practices in Agricultural Land.*	X					1977	Environmental Coordination Services Funding
PC1	Alberta Research Council	T. Macyk, Soil Division (Advisor)	*Research plots, planning and reclamation of McIntyre Mine No. 8, Grande Cache.*	X	X	X	X	X	1971 + continuous	McIntyre Mines Ltd.

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P 2	Alberta Energy and Natural Resources, Forest Service	Forest Land Use Branch	*Pilot project to predict capability of forest areas to be reclaimed within reasonable time limits. Determination of alternate resource values.*	X			X		1976 + continuous	
P 4	Alberta Energy and Natural Resources, Forest Service	Bow/Crow District Forest Staff	*Reclamation of abandoned mine at Ribbon Creek, Kananaskis Area.*	X				X	1976-77	
U 2	University of Alberta	J. Root, M.A. Thesis	*Physical environment of an abandoned strip mine near Cadomin, Alberta.*	X	X		X		1972-73	
U 2	University of Alberta	W. Shultz Rural Economy	*Reclamation of agricultural land in Prairie coal regions.*	X					1975 +	
U 2	Olds College	E. B. Martin	*Forage mixture trials - revegetation.*	X	X		X		1973 +	
U 3	University of Alberta	N. R. Morganstern Engineering Dept.	*Geotechnical aspects of mine waste disposal.*	X	X		X		continuous	

P2	Alberta Environment, Research Secretariat Alberta Research Council	T. Laidlaw, Northern Alberta Institute of Technology	*Studies on the use of trembling aspen for reclamation: propagation techniques.*		X	X		1973-74	
F 2	Indian & Northern Affairs	Parks Canada	*Reclamation of gravel pits, Banff and Jasper National Parks.*				X	1973-76	
FC1	Environment Canada, Environmental Management Service	Canadian Wildlife Service, Edmonton	*Wabamun Coal Mine reclamation for wildlife use.*				X	1976 +	Manalta Coal Ltd.
FC3	Environment Canada, Canadian Forestry Service	Northern Forest Research Centre	*Road Bank Stabilization - Hinton, Edmonton area.*				X	1974-76	North Western Pulp and Power Ltd.
PC1	Alberta Energy and Natural Resources	Forest Service	*Research plots, planning and reclamation of Racehorse Strip Mine.*	X	X	X	X	1974-77	Coleman Colleries Ltd.
P4	Alberta Energy and Natural Resources - Forestry Service	Norwest Soil Research Ltd.	*Reclamation of Nispi Spill area, Nez Perce.*		X	X	X	1972-77	
U2	University of Calgary	D. K. Headon Geography Dept.	*Physical Site Parameters of abandoned coal mine spoil heaps. Coleman, Alberta.*		X	X		1976-79	
FP2	Energy, Mines and Resources Geological Survey of Canada	L. E. Jackson Terrain Sciences Division, Calgary	*Slope stability and revegetation studies on coal mine wastes in Foothills and Front Ranges of the Rocky Mountains.*		X	X		1977-80	Alberta Research Council.

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F 2	Environment Canada Canadian Forestry Service	W. O. Holland, Northern Forest Research Station; G. A. Coen, Soil Survey, Canada Agriculture	*Reclamation plan for Waterton Lakes National Park.*	X			X		1973-74	Parks Canada Agriculture Canada
FC2	Environment Canada Canadian Forestry Service	G. L. Lesko, H. M. Etter Northern Forest Research Centre, Edmonton	*Revegetation research, trials on tar sands tailings, Fort McMurray, Alberta.*		X		X		1973-74	Great Canadian Oil Sands Co.
FP2	Environment Canada Canadian Forestry Service	G. L. Lesko Northern Forest Research Centre, Edmonton	*Species suitability research for sand dune reclamation at Lesser Slave Lake, Alberta.*		X		X		1973-74	Alberta Recreation Parks, Wildlife
FC2	Environment Canada Canadian Forestry Service	G. L. Lesko H. M. Etter T. M. Dillon Northern Forest Research Centre	*Species suitability research and reclamation of coal mine spoils at Luscar, Alberta.*		X		X	X	1969-75	Cardinal River Coals Ltd.
FP2	Alberta Energy and National Resources, Environment Canada	C. B. Berry	*1. Revegetation test plots on tailings dyke pond.* *2. Development of guidelines and plan for reclamation of disturbed land.*		X		X		1970-74	Great Canadian Oil Sands Ltd.

P2	Alberta Environment, Land Conservation and Reclamation Division	G. R. Shelley and Assoc. Ltd. Hydrology Consultants Ltd. Pedology Consultants Ltd. Shultz International Ltd.	*Preparation of a master development and reclamation strategy for lands in the vicinity of Villeneuve, Alberta*	X	X	X		1976-77	Environmental Coordination Services Funding
F 3	Department of Indian and Northern Affairs, Parks Canada	Western Region J. Peepre Calgary	*Native Materials Program: test collection methods; growth of native plants; their use for reclamation and reclamation techniques for their transplant.*						
F 3			• *Long Beach North, Pacific Rim National Park;*		X	X	X	1978-79	
F 3			• *Maligne Lake, Jasper National Park;*			X	X	1976-79	
F 3			• *Jasper Forest Recovery Program, transplanting native species.*			X		1978 +	
PC2	Alberta Reclamation Research Technical Advisory Committee	T. M. Macyk Alberta Research Council	*Revegetation of ash disposal pits. McIntyre Mines, Grand Cache*		X	X		1979-82	McIntyre Mines Ltd.
P2	Alberta Forest Service/ Alberta Reclamation Research Technical Advisory Committee	S. K. Takyi, P. King Alberta Forest Service	*Selection of woody plants for Oil Sand Reclamation*	X	X			1979 +	

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P2	Alberta Forest Service/ Alberta Reclamation Research Technical Advisory Committee	P. King Alberta Forest Service	*Establishment of tree and shrub seedlings in erosion controlling cover. Coal branch, Crowsnest*				X		1979 +	
P2	Alberta Forest Service/ Alberta Reclamation Research Technical Advisory Committee	S. K. Takyi Alberta Forest Service	*Use of Mat Mulches on difficult slopes. Cadomin.*				X		1979 +	
P2	Alberta Forest Service/ Alberta Reclamation Research Technical Advisory Committee	H. Tomm Alberta Forest Service	*Evaluation of Native-Agronomic grass and legume mixes, for reclamation at Sub-alpine Disturbances. Cadomin.*				X		1979 +	
P2	Alberta Forest Service/ Alberta Reclamation Research Technical Advisory Committee		*Methods of establishing native grass on unamended coal spoil, Cadomin.*				X		1980-85	
P2	Alberta Forest Service/ Alberta Reclamation Research Technical Advisory Committee	P. King Alberta Forest Service	*Native Shrub Seed Propagation Testing Project.*	X	X				1980	
P2	Alberta Reclamation Research Technical Advisory Committee	B. Markham Wildlife Habitat Inventory & Development Branch	*Integrated reclamation for Wildlife and Agriculture: Literature Review.*	X					1980	

P2	Alberta Reclamation Research Technical Advisory Committee	R. Sadasivaiah U. of Alberta P. Ziemkiewicz Alberta Energy and Natural Resources	*Selected lines of native grasses Alpine and Subalpine test plots.*				X	1979 +	
PC2	Alberta Reclamation Research Technical Advisory Committee/ OSESG	R. Johnson Montreal Engineering Co. Ltd.	*Requirements of reconstructed soils on Oil Sand Solid Tailings: Literature Review*	X				1979-80	Oil Sands Environmental Study Group (OSESG). Syncrude Suncor, Petro-Canada, and Alsands Ltd.
P2	Alberta Reclamation Research Technical Advisory Committee	H. P. Sims Alberta Environment	*Review and presentation of Reclamation information pertinent to Alberta.*	X				1978-81	
P2	Alberta Reclamation Research Technical Advisory Committee	S. R. Moran Alberta Research Council	*Hydrological Impacts of Plains Surface Coal Mining.*		X		X	1979 +	Luscar Ltd., Manalta Coal Ltd. Kananaskis Centre, U. of Calgary
PC2	Alberta Reclamation Research Technical Advisory Committee	T. Schori Techman Ltd. F. Reid Pedology Consultants	*Techniques for restoring crop production after surface mining.*				X	1979 +	Alberta Power Ltd., Luscar Ltd. and Manalta Coal Ltd.
P2	Alberta Reclamation Research Technical Advisory Committee	G. W. Hodgson Kananaskis Centre, U. of Calgary	*Biogeochemical Processes in Plains Coal Mine Spoil.*		X			1980-82	
PF3	Alberta Reclamation Research Technical Advisory Committee	J. Weijer R. Sadasivaiah Genetics Dept., U. of Alberta	*Development of Native Grasses for Reclamation. Ellerslie.*		X	X	X	1974 +	Parks Canada

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P2	Alberta Reclamation Research Technical Advisory Committee	D. Parkinson Biology Dept., U. of Calgary	*Establishment of Biological activity in Coal Mining Spoil and Sand Solid Tailings.*		X	X	X		1975-80	
P2	Alberta Reclamation Research Technical Advisory Committee	D. G. Walker David Walker Assoc. Ltd.	*Development of cross-reference system for Reclamation Review.*	X					1980-81	
P2	Alberta Reclamation Research Technical Advisory Committee	H. P. Sims Alberta Environment	*Update of "Reclamation Activities in Alberta".*						1980	
P3	Alberta Environment/ Alberta Reclamation Research Technical Advisory Committee	D. McCoy Alberta Environment	*Chemical characterization of bottom and fly ash from five power stations.*		X				1979-80	
P2	Alberta Environment/ Alberta Reclamation Research Technical Advisory Committee	D. McCoy Alberta Environment	*Fly ash and bottom ash use as a soil amendment.*		X	X			1979-80	
P2	Alberta Environment/ Alberta Reclamation Research Technical Advisory Committee	J. Fujikawa Alberta Environment	*Physical and chemical changes in stockpiled topsoil.*		X		X		1979-82	

P3	Alberta Environment/ Alberta Reclamation Research Technical Advisory Committee	D. McCoy Alberta Environment	*Radioactivity levels in coal ash.*		X		1980
P3	Alberta Reclamation Research Technical Advisory Committee	G. W. Hodgson Kananaskis Centre, U. of Calgary	*Literature Review: Effects of Organic compounds on groundwater salinization after surface coal mining.*	X			1979
P3	Alberta Reclamation Research Technical Advisory Committee	D. Pluth, J. Robertson U. of Alberta	*Physical and chemical characteristics of Bottom and Fly Ash.*		X		1978
P3	Alberta Reclamation Research Technical Advisory Committee	P. D. Lulman, M. J. Rowell LGL Ltd.	*Survey: Enhancement of plant growth by root-microorganism association.*		X	X	1979
P2	Alberta Reclamation Research Technical Advisory Committee	L. E. Watson, D. Plaster, R. Parker Techman Ltd.	*Species suitability manual for reclamation in Alberta.*	X			1979-80
PX2	Alberta Reclamation Research Technical Advisory Committee/ Oil Sands Environmental Study Group	J. Hastir Hardy and Assoc.	*Pipeline Construction and Reclamation Methods for Agricultural Land.*	X		X	1981
PX2	Alberta Reclamation Research Technical Advisory Committee/ Oil Sands Environmental Study Group	R. Hermesh Techman Ltd.	*Establishment and maintenance procedures for oil sand tree and shrub plantings.*	X			1982

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				LI	LAB	GSE	FLD	RCL		
PX2	Alberta Reclamation Research Technical Advisory Committee/ Oil Sands Environmental Study Group	R. Hermesh Techman Ltd.	*Review of shrub propagation techniques.*	X					1981	
PC2	Alberta Reclamation Research Technical Advisory Committee/ Oil Sands Environmental Advisory Group	D. Klym, Suncor P. King, Alberta Forest Service	*Seed collection for shrub and tree program.*				X		1981	
PX2	Alberta Reclamation Research Technical Advisory Committee/ Oil Sands Environmental Advisory Group	M. Rowell, Norwest Soil Research Ltd.	*Review of sampling methods for shrub and tree program.*	X					1981	
P3	Alberta Reclamation Research Technical Advisory Committee/ Public Lands Division	D. Lloyd Public Lands Division	*Methods for controlling erosion on sandy sites.*				X		1982	
P2	Alberta Reclamation Research Technical Advisory Committee	P. Ziemkiewicz, S. Takyi, Alberta Energy and Natural Resources	*Nutrient cycling on coal spoils.*				X		1982	
P2	Alberta Forest Service/Reclamation Research Technical Advisory Committee	M. Mihajlovich	*Survey of Alberta Forest Service native grass trails.*				X		1982	

F2	Parks Canada, Western Region, Calgary Environment Canada	David Walker and Associates Ltd. Edmonton	*Bow Valley Parkway Rehabilitation Trials*			X	1979-84	
F2			- *Flint Park Road Seeding Trial*			X	1978-83	
F2			- *Windy Point Revegetation Research; Jasper Flats*			X	1977-82	
F2			- *Backcountry Revegetation Trials, Banff National Park, Banff*			X	1975-85	
P2	Alberta Environment Planning Division	Devonian Botanic Garden, Dept. of Botany, University of Alberta	*Native plant material for site development.*	X	X	X	1980-83	Alberta Parks and Recreation; Provincial Parks Division; Operations and Maintenance Branch.
P2	Alberta Environment	Earth Sciences Division; Planning Division	*Reclamation of Sodic Mine spoils*	X	X	X	1976 +	
F2	Agriculture Canada	Lethbridge Research Station	*Characterization of the structure of strip mine spoils as a basis for improving their productivity.*	X	X	X	1980-85	
P2	Alberta Fish and Wildlife Division, Energy and Natural Resources	David Walker and Associates Ltd.	*Ya Ha Tinda Ranch Native Grass Seeding Study*	X		X	1980 +	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	 LAB	 GSE	 FLD	 RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
P2	Alberta Fish and Wildlife Division, Energy and Natural Resources	David Walker and Associates Ltd.	*Athabasca Ranch Elk Winter Range Improvement Study*	X			X		1979-81	
P2	Water Resources Div., Alberta Environment	Devonian Botanic Garden, Botany Dept., University of Alberta	*Revegetation capabilities of Native Dryland Forbs.*	X	X		X		1980-83	Alberta Environment Planning Div., Alberta Recreation and Parks, Provincial Parks Div.
U2	University of Alberta	D. G. Walker R. L. Rothwell	*Temperature Stability of chemical soil tackifiers*	X	X		X		1980-81	
P4	Alberta Energy and Natural Resources. Reforestation and Reclamation Branch	Beak Consultants Ltd., Calgary	*Kananaskis Country Road Reclamation Plans. Kananaskis Provincial Park.*	X				X	1978-81	
P4			*Campsites and Day-Use Areas in Kananaskis Country*	X				X	1978-81	
UC3	David Walker and Associates, Calgary, University of Alberta	David Walker and Associates	*Vegetative Propagation of Native Woody Species for reclamation*	X	X		X		1980-81	Village Lake Louise
UC3		R. H. Hillson, Dept. of Forestry, Univ. of Alberta	*Seed propogation of native wood species for reclamation*		X				1980-81	Village Lake Louise

F3	Parks Canada Western Region, Calgary Environment Canada	Laidlaw Vegetation Consulting Ltd., Tofield	*Propogation of native shrubs for Bow Valley Corridor and Maligne Lake Road*		X			1980-82	
F3	Parks Canada Western Region, Calgary Environment Canada	MTB Consultants Ltd. Edmonton	*Materials Source Study: Banff National Park*	X	X	X		1979-80	
F3			*Maligne Canyon Reclamation Project. Jasper National Park*	X		X	X	1980-81	
U2	University of Alberta	W. Russell: G. La Roi; Botany Dept.	*Vascular flora and native vegetation of abandoned coal mined land. Rocky Mountain Foothills.*	X	X	X		1977-80	
U2	University of Alberta	D. M. Wishart Dept. of Forest Science	*Revegetation in a montane grassland.*	X	X		X		1977-81

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY					DURATION	COOPERATIVE AGENCY OR INDUSTRY
				LI	LAB	GSE	FLD	RCL		
P4	Alberta Environment	Land Surface Conservation and Reclamation Div.	*Operational Reclamation:*							
			• *Forestburg South Phase*					X	1980	
			• *Myrtle Roberts Mine Cave-in*					X	1980	
			• *Cherniwachan Mine Hazard*					X	1980	
			• *Garstad Mine Hazard*					X	1980	
			• *Nick Pholka Mine*					X	1980	
			• *St. Paul Borrow Pit*					X	1980	
			• *Cardiff Park Mine Subsidence*					X	1980	
			• *Muskeg River Gravel Pit*					X	1980	
			• *Moonlake Gravel Pit*					X	1980	
			• *Cucumber Lake Gravel Pit*					X	1980	
			• *Delburne Gravel Pit*					X	1980	
			• *Reed Gravel Pit*					X	1980	

			• *Valleyview Gravel Pit*		X	1980	
			• *Vermillion Park Gravel Pit*		X	1980	
			• *Thorhild Gravel Pit*		X	1980	
			• *Bow City Strip Mine*		X	1980	
			• *Forestbury Strip Mine North*		X	1980	
			• *Forestbury Strip Mine South*		X	1980	
PC2	Alberta Energy and Natural Resources, Alberta Forest Service	Reforestation and Reclamation Branch	• *Native grass broadcast seeding trial*	X		1976-81	Coleman Colleries Ltd.
PC2			• *Tent Mountain 5 – Tree and shrub bare-root stock planting trial*	X		1976-81	Coleman Colleries Ltd.
PC2			• *Tent Mountain 9 – Container stock planting trial*	X		1977-82	Coleman Colleries Ltd.
PC2			• *Tent Mountain 10 – Agronomic species adaptability trial*	X		1977-82	Coleman Colleries Ltd.
PC2			• *Tent Mountain 11 – Aspen green alder container stock planting trial*	X		1977-82	Coleman Colleries Ltd.

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY					DURATION	COOPERATIVE AGENCY OR INDUSTRY
				LI	LAB	GSE	FLD	RCL		
PC2	Alberta Energy and Natural Resources, Alberta Forest Service	Reforestation Reclamation Branch	• *Native grass seed mixture trials*				X		1978-83	Luscar Ltd.
PC2			• *Native grass adaptability trials*				X		1978-83	Luscar Ltd.
PC2			• *Agronomic Grass and Legume Adaptability Trials*				X		1978-83	Luscar Ltd.
PC2			• *Agronomic Seed Mixture Trials*				X		1978-83	Luscar Ltd.
PC2			• *Species Selection Trials*				X		1977 +	Suncor Inc. Oil Sands Division
PC2			• *Scarification and Fertilization Trial*				X		1977 +	Suncor Inc. Oil Sands Division
PC2			• *Response to overburden ground cover trial*				X		1977 +	Suncor Inc. Oil Sands Division
PC2			• *Overburden amendments trial*				X		1977 +	Suncor Inc. Oil Sands Division
PC2			• *Overburden fertilizer response trial*				X		1977 +	Suncor Inc. Oil Sands Division

F3	Energy Mines and Resources Canada, Canada Centre for Mineral and Energy Technology	Techman Ltd. Calgary	*Compile comprehensive review on specialized equipment which might be suitable for reclaiming various types of mine wastes*	X				1979	

BRITISH COLUMBIA

PC 2	B.C. Ministry of Mines and Petroleum Resources, Inspection and Engineering Branch	L. M. Lavkulich, Soil Science Dept., University of B.C.	*Heavy metals and long-term nutrient update by vegetation on mine tailings at H.B. and Sullivan Mines.*	X	X	X	X	1976-80	Cominco Ltd.
P 2	B.C. Dept. of Environment Environmental Land Use Committee	J. Errington, Reclamation Division B.C. Dept. of Mines and Petroleum Resources	*Preparation of a manual for environmental protection and reclamation techniques for exploration and mining activities.*	X				1977-78	
P 2	B.C. Dept. of Environment Environmental Land Use Committee	J. Walker, Habitat Protection Branch, Fish and Wildlife Branch, Min. Recreation and Conservation	*Preparation of a reclamation program for wildlife purposes.*	X				1977	
F2	National Research Council of Canada; Energy Mines and Resources, Canada Centre for Mineral and Energy Technology	G. W. Poling, Mineral Engineering Dept., University of B.C.	*Sedimentation characteristics of mill tailings. Surface chemical stabilization of tailing dam sediments.*		X		X	1972-77	
U 2	University of British Columbia	J. C. Errington, PhD. Thesis, Forestry Dept.	*Natural revegetation of Disturbed Sites in B.C.*	X	X		X	1972-75	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	LAB	GSE	FLD	RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
UC1	University of British Columbia	F. J. Lowenberger, M.Sc. Thesis, Forestry Dept.	*Reclamation of strip mined overburden through tree planting; Michel and Natal, Southeast B.C.*		X		X		1972-73	Kaiser Resources Ltd.
P 2	British Columbia Ministry of Mines and Petroleum Resources, Inspection and Engineering Division	Reclamation Section	*Preparation of general revegetation guidelines for coal and mineral exploitation.*	X					1976-77	
PC2	B.C. Ministry of Recreation and Conservation, Fish and Wildlife Branch	M.G. Stanlake, E. A. Stanlake, P. S. Eastman, Victoria	*Study to compare wildlife use on reclaimed stripmines with adjacent undisturbed habitats.*		X		X		1974-76	Fording Coal Ltd. Kaiser Resources Ltd.
			- Study to assess species composition and forage yields on reclaimed strip mines.		X		X		1974-76	
			- Study the effects of coal exploration activities on ungulate winter range.				X		1974-76	
U 2	University of British Columbia	J. V. Thirgood Forestry Department	*Reclamation research (revegetation seed trials) at Kitsault Molybdenum Mine, B.C.*		X		X		1970-75	

P 1	British Columbia Ministry of Mines and Petroleum Resources	A. O'Bryan Reclamation Section	*Reclamation program. metallic mine tailings at Emerold Mine Salmo, B.C.*		X		X	X	1978	
PC1	British Columbia Ministry of Mines and Petroleum Resources	J. D. McDonald, Reclamation Section	*Reclamation of tailings using sewage effluent. Grandby Tailings, Princeton, B.C.*	X	X		X	X	1978 +	Village of Princeton Shultz International
PC2	British Columbia Ministry of Mines and Petroleum Resources Inspection and Engineering Division	J. C. Errington, Reclamation Section Staff	*Field trials for surface revegetation of disturbed land and reclamation planning for Northeast Coal Block, B.C.*		X		X		1976	
PU2	B.C. Ministry of Mines and Petroleum Resources, Inspection and Engineering Branch	W. F. Hubbard, M. A. M. Bell, Biocon Research Ltd., Victoria	*Preparation of a bibliography and review of the state of the art on reclamation techniques for mountainous and northern areas.*	X					1976-77	
P 2	B.C. Dept. Environment Environmental Land Use Committee	M. Galbraith, Reclamation Div. Inspection and Engineering Branch B.C. Ministry of Mines and Petroleum Resources	*Airphoto Inventory of Surface Disturbances in N.E. Coal Block, B.C.*		X		X	X	1977	
F3	Environment Canada, Environmental Protection Service	R. D. Cameron, N. Vancouver, B.C.	*Identification of policy options regarding the discharge of wastes on land.*	X					1977-78	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	LAB	GSE	FLD	RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
UC1	University of B.C.	R. J. Berdusco, B.Sc. F. Thesis, Forestry Dept.	*Study on the ecological economics and social implications of reclaiming 3 old surface coal mines, Crowsnest Pass, B.C.*	X	X		X		1973-74	Kaiser Resources Ltd.
FC2	Energy, Mines and Resources CANMET/Pit Slope Project	L. Lavkulich, Soil Science Dept. University of British Columbia	*Pedological inventory of mining wastes. Cooperative Revegetation Program.*		X		X		1974-76	1. Newmont Mines Ltd. 2. Gibraltar Mines Ltd. 3. Brenda Mines Ltd. 4. Lornex Mining Corp. Ltd. 5. Bethlehem Copper Corp. Ltd. 6. Kaiser Resources Ltd. 7. Similkameen Mining Co.
UC2	University of British Columbia	P. F. Ziemkiewicz, Forestry Dept. Ph.D. Thesis	*Nutrient and organic matter dynamics on reclaimed coal mines and native grasslands.*		X		X		1975-77	Kaiser Resources Ltd.
F2	National Research Council of Canada	J. Weir-Jones, Dept. Mining Engineering, University of British Columbia	*Chemical stabilization of tailings dams.*		X		X		1972-73	
F3	National Research Council of Canada	J. Walters, Forestry Dept. University of British Columbia	*Reforestation by containerized aerial seeding.*		X		X		1974-75	

F3	National Research Council of Canada	C. J. Krebs, Resource Ecology Dept., University of British Columbia	*Behaviour of disturbed ecological systems.*		X	X	1975-76	
FC2	Energy, Mines and Resources, Canada CANMET/Pit Slope Project	L. Lavkulich, Soil Science Dept. University of British Columbia	*Pedological inventory of sulphide mine wastes at 3 British Columbia mine sites. Cooperative Revegetation Program.*		X	X	1975-76	Texado Mines and Coast Copper Mine Endako Mines.
P2	British Columbia Hydro and Power Authority	Acres Consulting Services R. L. Docksteader D. K. McQueen	*Revegetation trials at proposed Hat Creek Coal project, Cashe Creek*			X	1977 +	
UC2	University of Victoria	M. A. M. Bell Biology Department. University of Victoria	*Revegetation tests on high elevation coal mine wastes in S.E. British Columbia.*	X		X	1979-81	Kaiser Resources Ltd.
P2	B.C. Ministry of Mines and Petroleum Resources Inspection Division	M. A. M. Bell Biology Department	*Vegetation and Soil Development on high elevation exploration disturbances in N.E. Coal Block.*	X		X	1978-79	
U 2	University of Victoria	M. A. M. Bell Biology Department	*Microtopography influence on revegetation of tailings ponds.*	X		X	1978-79	
P 2	British Columbia Ministry of Environment	T. Vold Resource Analysis Branch	*Literature review of soil properties affecting reclamation.*	X			1979-80	

F3	Department Indian and Northern Affairs, Parks Canada	G. W. Scalter, S. E. Campbell, Canadian Wildlife Service, Environment Canada	*Subalpine revegetation and disturbance studies, Mt. Revelstoke National Park*		X		1974-79	
F3	Department Indian and Northern Affairs, Parks Canada	Western Regional Office, Calgary	*Mt. Revelstoke National Park. Use of plug or matt forming herbaerous species*		X	X	1976	
U2	University of Victoria	Dept. Biology D. R. Meidinger	*Natural Revegetation of disturbances in the Peace River coal field, British Columbia*	X	X		1977-78	
UC2	S. Ames Dept. Soil Science		*Migration of acid substances in Sullivan Tailings; A column study.*	X			1978	Cominco Ltd.

YUKON AND N.W.T.

F 2	Public Works Canada		*Mackenzie Highway Revegetation Trials to Compare and analyse different methods designed to give guidance for revegetation program for Highway.*	X	X		1973-74	

F2	Public Works Canada	Lombard North Group	*Evaluation of the results of the Public Works Canada Mackenzie Highway revegetation pilot program at Fort Simpson and Inuvik.*	X		1975-76	
F 3	Dept. Indian Affairs and Northern Development, Environmental Social Program — Northern Pipelines	S. C. Zoltai, Canadian Forestry Service, Northern Forest Research Centre, Edmonton	*Vegetation, terrain permafrost relationships in arctic, Somerset and Prince Wales Islands. Identification of terrain sensitive to disturbance by activities related to development.*	X	X	1971-78	
F 3	Environment Canada, Canadian Forestry Service	T. G. Honer, Pacific Forest Research Centre, Victoria	*Baseline data collection and studies on forest resources in Yukon, to evaluate and prescribe reforestation techniques for environmentally sensitive areas.*	X	X	1975-82	Yukon Lands and Forest Service, Dept. Indian Affairs and Northern Development.
F3	National Research Council of Canada	L. B. Bliss, Botany Dept., University of Alberta	*Primary productivity and the effects of disturbance on primary production in arctic ecosystem.*	X	X	1972-73	
F3	Dept. Indian Affairs and Northern Development Arctic Land Use Research Program	L. C. Bliss, Botany Dept., University of Alberta	*Effects of perturbation on plant communities; a quantitative approach to the potential for revegetation in the High Arctic.*	X	X	1972-73	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	LAB	GSE	FLD	RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
F3	Dept. Indian Affairs and Northern Development Arctic Land Use Research	G. Leduc, Biological Sciences Dept., Laurentian University	*Toxicity studies of arsenic and cyanide associated with northern mining operations.*		X		X		1975-76	
F3	Environment Canada Environmental Protection Service	R. A. Smith, Geology Dept., University of Alberta	*Survey and analysis of the nature and extent of heavy metal contamination of soils and vegetation in the Yellowknife area.*		X		X		1975-76	
F3	Dept. Indian Affairs and Northern Development; Energy, Mines and Resources, Geological Survey of Canada	H. Halstead, (Agriculture Canada) R. A. White, Saskatchewan Institute of Pedology, Saskatoon	*Describe and map the distribution of soils, and to recommend measures for mitigating damage to the soils under difficult uses.*		X		X		1975-76	
F 3	Dept. Indian Affairs and Northern Development	Interdisciplinary Systems Ltd., Edmonton	*Development of land use Guidelines for mineral exploration in the Northwest and Yukon Territories.*	X					1981-82	
F 2	Dept. Indian Affairs and Northern Development Environmental Social Program Northern Pipelines	S. C. Zoltai, R. Strong, C. Crampton, Northern Forest Research Station, Environment Canada Geological Survey of Canada	*Mackenzie Valley Terrain Sensitivity Studies to determine 1. Reactions of Arctic and subarctic vegetation and soil to various disturbances, 2. Techniques contributing to the main tendance and restoration of surface stability.*		X		X		1971-73	

F 3	Same as above	J. A. Heginbottom, P. J. Kurfurst Terrain Sciences Division, Geological Survey of Canada	*Terrain sensitivity studies. Effect of ground surface disturbances on surfical materials in Mackenzie Valley transportation Corridor. — Erosion studies on permafrost areas affected by man's activities.*	X	X	1974-77
F 2	Same as above	E. B. Owen, D. W. Van Eyk Northern Natural Resources and Environment Branch	*Study to assess the terrain damage by pipeline installation and methods undertaken to rehabilitate the damage (Pointed Mountain Gas Pipeline).*	X	X	1974
U 2	University of Alberta, Boreal Institute for Northern Studies	K. W. Gullen	*Research study to determine types of vegetation suitable to reclaim tailings areas at 2 mines near Carcross, Yukon Territory.*	X	X	1975-76
F 2	Dept. Indian and Northern Affairs, Arctic Land Use Research Program	H. Hernandez, Canadian Environmental Protection Board	*Revegetation studies at Norman Wells, Inuvik and Tuktoyaktuk, N.W.T.*	X	X	1972-73
F 2	Canada, Dept. Indian and Northern Affairs, Water Resources Section, Whitehorse	D. A. Bayne	*Revegetation test plots on tailings areas at vacated mines near Carcross, Yukon Territory.*	X	X	1973-75

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY LI	LAB	GSE	FLD	RCL	DURATION	COOPERATIVE AGENCY OR INDUSTRY
F 3	Environment Canada Environmental Protection	Northwest and Pacific Regional Offices	*Development of guidelines for the preparation of Environmental Impact and Assessment reports for proposed Mining Developments in the North.*	X					1975-76	Territorial Water Boards
F2	Dept. Indian Affairs and Northern Development	B. Larsen Town Planning and Lands Division, Yellowknife	*Revegetation test plots on abandoned gravel pits, Norman Wells and Tuktoyaktuk.*				X		1981 +	
F2	Dept. Indian Affairs and Northern Development	MacLaren Plansearch Services Ltd., Edmonton	*Research and produce a guide to site development and rehabilitation of pits and quarries in Yukon and Northwest Territories.*	X					1982	
F2	Canada Department of Indian and Northern Affairs, Arctic Land Use Research Program	L. C. Bliss, R. W. Wein, Botany Dept., University of Alberta (H. Hernandez, W. E. Younkin, J. A. Babb)	*Revegetation studies of disturbances in the Eastern Mackenzie Delta and Arctic Islands.*	X	X		X		1970-74	
F 2	Environment Canada, Environmental Protection Service and Canadian Forestry Service	H. J. B. Curran, H. M. Etter	*Revegetation guidelines for northern road development.*	X					1974	

U 2	University of Waterloo - Faculty of Environmental Design	G. P. Kershaw, M.A. Thesis	*Vegetation studies on old mine tailings and roads. Mactung Area, Yukon - N.W.T. Border.*	X	X	1974-76	
U 2	University of Alberta Geography Department	K. Taylor M.A. Thesis	*Studies on natural revegetation of tailings at Discovery Mine, N.W.T.*	X	X	1974-75	
F3	National Research Council of Canada	L. C. Bliss, Botany Dept., University of Alberta	*Primary productivity and the effect of disturbance on primary production in arctic ecosystem.*	X	X	1972-73	Canada Dept. of Indian Affairs and Northern Development.
F3	National Research Council of Canada	D. E. Kerfoot, Geography Dept., Brock University	*Tundra disturbance and geomorphic process studies in the Mackenzie Delta Area.*	X	X	1974-77	Canada Dept. of Indian Affairs and Northern Development.
F3	National Research Council of Canada	D. Gill, Geography Dept., University of Alberta	*Positive and negative aspects of artificial disturbances in the northern environment.*	X	X	1974-77	
F3	Canada, Dept. Indian Affairs and Northern Development, Arctic Land Use Research Program	K. A. Kershaw, Biology Dept. W. R. Rouse, B. T. Bunting, Geography Dept., University of Waterloo	*Studies on the effects of forest fire at east end of Great Slave Lake. Observations on the degree of revegetation.*	X	X	1972-76	
F3	Same as above	R. W. Wein, Biology Dept., University of New Brunswick	*Study to evaluate the effects of fire damage and the recovery rate of vegetation in Arctic Regions.*	X	X	1972-74	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY					DURATION	COOPERATIVE AGENCY OR INDUSTRY
				LI	LAB	GSE	FLD	RCL		
F2	Same as above	E. B. Peterson, N. M. Peterson, Western Ecological Services Ltd.	*Revegetation Information Applicable to mining sites in Northern Canada. Annotated Bibliography.*	X					1976-77	
F 2	Same as above	R. Fahlman, R. Edwards, Technical Branch, Environmental Protection Service Environment Canada Northwest Region	*Study to determine the effects of land sewage disposal on vegetation in Canada's North, and if such disposal may be beneficial for the renovation of disturbed areas.*		X		X		1973-74	
F2	Canada Department of Indian Affairs and Northern Development, Arctic Land Use Research Program	T. C. Hutchinson, A. K. Kuja; Univ. of Toronto; Botany Dept. and Institute for Environmental Studies	*Tailings reclamation of acidic and metal contaminated arctic sites using pre-adapted vegetation.*		X		X		1975-79	1. Arctic Gold and Silver Mines Ltd. 2. Cypress Anvil Mining Corp. 3. Canada Tungsten Mining Corp. Ltd. 4. Pine Point Mines Ltd. 5. Whitehorse Copper Mines Ltd. 6. Venus Mines Ltd. 7. Cominco Ltd., Yellowknife
F3	Same as above	D. W. Smith, Botany Dept., University of Guelph	*Biological changes resulting from terrain disturbances in Canadian Arctic.*		X		X		1977 continuous	

F2	Canada Dept. Indian and Northern Affairs, Arctic Land Use Research Program	J. D. H. Lambert, Biology Dept., Carleton University D. E. Kerfoot, Geography Dept., Brock University	*1. Studies to determine the long-term effects of terrain disturbances by seismic and drilling operations, off-road vehicles in Western Canadian Arctic.*	X	X	1971-75	National Research Council of Canada
F2		J. R. Radforth, Musking Research Inst., University of New Brunswick	*2. Determine extent and rate of vegetation recovery, surface subsidence, erosion and permafrost changes.*	X	X	1971-75	
F2	Same as above	P. Barrett, Biology Dept., Carleton University	*Studies of off-road vehicle disturbances, Devon, N.W.T. Natural revegetation and use of native species for reclamation.*	X	X	1973-74	
F2	Same as above	Y. Berube, M. Roy, S. Vezina, M. Frenette, R. Gilbert, C. Anctil, Centre de recherches sur l'eau, University Laval, Québec	*Studies of mining sites at Great Slave Lake and Yellowknife, N.W.T. Physical and chemical properties of mine tailings and water quality discharge.*	X	X	1972-73	
F3	Canada Dept. Indian and Northern Affairs, Arctic Land Use Research Program	J. S. Rowe, R. Hermesh, Plant Science Dept., G. A. Padbury, Saskatchewan Inst. Pedology; J. L. Bergsteinsson, Geography Dept., University of Saskatchewan	*Studies on the effects of forest fire at Fort Simpson and Norman Wells. Observations on the degree of revegetation, erosion and slumping on the damaged terrain.*	X	X	1975-76	

REF. CODE	INITIATING OR FUNDING AGENCY	PRINCIPAL AND/OR CONSULTANTS	TITLE	ACTIVITY					DURATION	COOPERATIVE AGENCY OR INDUSTRY
				LI	LAB	GSE	FLD	RCL		
F3	Dept. of Indian Affairs and Northern Development, Environmental Studies, Arctic Land use Research Program	Sroule Associates Ltd., Calgary, Alberta	*Preparation of Canadian Arctic Island Sensitivity Photomosaics. To establish the relative sensitivity of tolerances of various terrain units in the Arctic Islands to disturbance of surface conditions.*		X		X		1975-76	
F3	Dept. of Indian Affairs and Northern Development, Arctic Land Use Research Program	W. J. D. Stephen, Canadian Wildlife Service, Environment Canada, Edmonton	*1. Monitoring terrain disturbances to wetlands caused by highway construction in Mackenzie Valley.* *2. Evaluation of potential impact of mine waste disposal in Strathcona Sound.*		X		X		1975-76	

APPENDIX 13. SUMMARY OF RECLAMATION PROJECTS IN CANADA: According to Subject and Period of Commencement

	Province/Territory							
	Atlantic Provinces	Quebec	Ontario	Manitoba/ Saskatchewan	Alberta	British Columbia	Yukon & N.W.T.	CANADA
1 A	1			1	1	1		4
1 B	4			4	20	2		30
1 C	3			3	59	5		70
2 B	6	5	13			5	4	33
2 C	1		14	3		8	5	31
3 B			1		1			2
3 C	2		17	1	12		1	33
4 B			5					5
4 C			5					5
5 B					7			7
5 C		1			17			18
6 A			1					1
6 B			3		6	1	14	24
6 C	1	2	2	1	42	2	7	57
7 B		1						1
8 B						1	3	4
8 C	1	1	4		11	5	5	27
TOTAL	**19**	**10**	**65**	**13**	**176**	**30**	**39**	**352**

Subjects
1. Coal
2. Metals
3. Non-Metallic
4. Uranium
5. Oil Sands
6. Disturbances: Revegetation studies applicable to all types of disturbances including exploration, development, pipeline, hydro, vehicles, etc.
7. Asbestos
8. General: Canada wide reviews, reclamation manuals, bibliographies, planning.

Time Periods:

A. Pre 1970 Start.

B. Start Between 1970-74.

C. Post 1975 Start.

Source: Derived from the Inventory of Reclamation Projects Appendix 12

APPENDIX 14. SUMMARY OF RECLAMATION PROJECTS IN CANADA: According to Level of Program Involvement by Initiating or Funding Agency

	Province/Territory							
	Atlantic Provinces	Quebec	Ontario	Manitoba/ Saskatchewan	Alberta	British Columbia	Yukon & N.W.T.	CANADA
F 1	1				1			2
F 2	2		7	2	8	3	17	39
F 3	2	2	9	1	6	3	19	42
FP 2	1				3			4
FP 3					1			1
FP 4					1			1
FC 1	1		2	1	1			5
FC 2	3	6	7	1	3	2		22
FC 3			2		1			3
P 1	2		4	2	6	1		15
P 2	3		12	2	56	9		82
P 3			1		18			19
P 4			1	1	31			33
PF 1	1		1					2
PF 2					6			6
PF 3					2			2
PU 1			1	1				2
PC 1	2				2	1		5
PC 2			2		18	2		22
PC 3			1					1
U 2		1	3	1	4	4	3	16
UC 1			4			2		6
UC 2					3	3		6
UC 3					3			3
CP 1	1		4					5
CP 2					1			1
CP 4			1					1
CU 1		1	3	1				5
CU 2					1			1
TOTAL	**19**	**10**	**65**	**13**	**176**	**30**	**39**	**352**

Initiating or Funding Agency:

F - Federal Government Department/Agency
P - Provincial Government Department/Agency
U - University Department/Research Centre
C - Company Research Department

Level of Research Involvement:

1 - Actual Site Reclamation Combined with Research Program
2 - Directly Related Research Designed to Reclaim Mining Disturbance
3 - Indirectly Related Research — Research results that could be applied to reclaim various land disturbances
4 - Site Reclamation Only

Source: Derived from the Inventory of Reclamation Projects Appendix 12

APPENDIX 15. SUMMARY OF UNIVERSITY INVOLVEMENT IN RECLAMATION PROJECTS:

According to Subject and Period of Commencement

	Province/Territory							
	Atlantic Provinces	Quebec	Ontario	Manitoba/ Saskatchewan	Alberta	British Columbia	Yukon & N.W.T.	CANADA
1 A				1				1
1 B		1		1	2	2		6
1 C				1	8	3		12
2 B		1	10			5	4	18
2 C			9	1		4	3	17
3 B			1					1
3 C		1	9					10
4 B								
4 C			1					1
5 B		1			3			4
5 C					1			1
6 A					1		1	2
6 B			1		3	1	9	14
6 C		2	1		12	1	2	18
7 B		1						1
8 C					2	1		3
TOTAL		7	32	4	32	17	19	111

Subjects:

1. Coal
2. Metals
3. Non-Metallic
4. Uranium
5. Oil Sands
6. Disturbances: Revegetation studies applicable to all types of disturbances including exploration, development, pipeline, hydro, vehicles, etc.
7. Asbestos
8. General: Canada wide reviews, bibliographies, planning.

Time Periods:

A. Pre 1970 Start.

B. Start Between 1970-74.

C. Post 1975 Start.

Source: Derived from the Inventory of Reclamation Projects Appendix 12

APPENDIX 16: INVENTORY OF RECLAMATION ACTIVITIES AT CANADIAN MINE SITES

The list of mines presented here is not exhaustive, nor was it possible to attempt a systematic review of all the former and currently operating companies involved in reclamation activities today. The inventory is aimed at providing an indication of the growth and current direction of reclamation activities in the mining industry. However, all reclamation programs established by individual mining companies were included where sufficient details were available. Due to the vast number of individual mineral aggregate extraction operations in Canada (in particular sand, gravel and crushed stone). it was not possible to include them in this inventory. The inventory includes 157 individual mine sites (January, 1981). Many companies have several mine sites and research is often centred on one or two of the mines, but may be designed to apply to other sites as well.

EIA: Indicates that biophysical inventories of the mine site were conducted. Including the analysis of physical chemical and biological conditions, and the identification of limiting factors to reclamation.

FLD: Indicates reclamation field trials.

RCL: Indicates successfully reclaimed disturbances.

Cooperative Agency/Consultant: Indicates that the company utilized consulting assistance, or cooperated in federal, provincial or university research programs, in addition to its own reclamation activities.

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
NEWFOUNDLAND - LABRADOR					
Iron Ore Co. of Canada, Labrador City Carol Lake, Humphrey Small Wood Mines	N.B. Research and Productivity Council	X	X		1974
Pickands, Mather & Co., Scully Mine, Wabush Mines Ltd.	N.B. Research and Productivity Council	X	X	X	1971
ASARCO Incorporated Buchan's Mine, Grand Falls	Newfoundland Forest Research Center. Canadian Forest Service, Environmental Protection Service, Environment Canada	X	X	X	1973
Consolidated Rambler Ming Mine, Baie Verte	Erocon Ltd.; Water Pollution Control Division, Environment Canada	X	X	X	1977

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
NOVA SCOTIA					
Thorburn Mining Ltd., Stellarton (Coal).	N.B. Research and Productivity Council.	X	X	X	1974
Cape Breton Development Corp (Coal)	N.B. Research and Productivity Council.				
Lingan Mine, Lingan		X			1974
No. 26 Colliery, Glace Bay		X			1974
Prince Mine, Pt. Aconi		X	X	X	1974
Abandoned mine sites,	N.S. Departments of Agriculture and Environment.				
Alder Point,		X	X	X	1975
New Waterford.		X	X	X	1975
Georgia Pacific Corp., Gypsum Mine, River Denys.	N.B. Research and Productivity Council.	X			1974
National Gypsum Ltd., Gypsum Mine, Milford Station.	N.B. Research and Productivity Council.	X			1974
NEW BRUNSWICK					
Heath Steele Mines Ltd. Newcastle	N.B. Productivity and Research Council. Mine Waste Reclamation Ltd. Guelph, Ontario	X	X		1974
Brunswick Mining and Smelting Corp. Ltd., Bathurst No. 6 and No. 12 mines.	N.B. Productivty and Research Council. Mine Waste Reclamation Ltd. Guelph, Ontario	X	X	X	1974
N.B. Coal Ltd., Minto-Chapman area.	N.B. Productivity and Research Council. Forestry, Fish and Wildlife Branch's Department of Natural Resources.	X	X	X	1967

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
QUEBEC					
Noranda Mines Ltd., Horne Mine	Soil Research Institute. Agriculture Canada. Crop Science Department, University of Guelph, Erocon Ltd. Mine Waste Reclamation Ltd. Guelph, Ont.	X	X	X	1969
Waite Amulet Mine.		X	X	X	1969
Kerr Addison. Quemont Mines Ltd.	Soil Research Institute, Agriculture Canada. Noranda Mines Ltd.	X	X	X	1974
Carey Canadian Mines Ltd. East Broughton Mine	Geography Department, McGill University, Quebec Asbestos Mining Association.	X	X		1971
Canadian Johns Manville Co. Ltd. Jeffrey Mine	Geography Department, McGill University, Quebec Asbestos Mining Association Erocon Ltd.	X	X		1971
Asbestos Corporation Ltd.	Geography Department, McGill University, Quebec Asbestos Mining Association.	X			1971
Lake Asbestos of Quebec Ltd. Black Lake	Geography Department, McGill University, Quebec Asbestos Mining Association.	X	X		1971
Gaspé Copper Mines Ltd. Copper Mountain Mine	N.B. Research and Productivity Council. Noranda Mines Ltd.	X	X	X	1958
Needle Mountain Mine		X			1974
Quebec Cartier Mining Co. Lac Jeannine, Gagnon	N.B. Research and Productivity Council.	X	X	X	1972
Rio Algom Ltd. Mines de Poirier, N. Amos	Université de Sherbrooke, Centre de technologie de l'environnement.	X			1974
Louvem Mining Co. Ltd. Manitou-Barrue Mine	Université de Sherbrooke, Centre de technologie de l'environnement.	X	X	X	1974
Mattagami Lake Mines Ltd. Orchan Mines Ltd., Mattagami (use same tailings ponds).	Université de Sherbrooke, Centre de technologie de l'environnement.	X	X	X	1970
Kerr Addison Mines Ltd. Normetal Mine.	Université de Sherbrooke, Centre de technologie de l'environnement. Noranda Mines Ltd.	X	X	X	1969
Camflo Mines Ltd. Malarctic.	Université de Sherbrooke, Centre de technologie de l'environnement.	X	X	X	1974

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
QUEBEC					
Lamarque Mining Co. Ltd. Bourlamarque Twp. Mine.	Université de Sherbrooke, Centre de technologie de l'environnement.	X	X		1972
Sigma Mines Ltd. Bourlamarque Twp. Mine.	Université de Sherbrooke, Centre de technologie de l'environnement.	X			1972
East Malarctic Mines Ltd. Barnat Mine.	Université de Sherbrooke, l'environnement.	X	X		1973
Hilton Mines Ltd. Shawville.	Geography Department, Carleton University.	X	X	X	1969
Falconbridge Copper Ltd. Lake Dufault Div., Millen-Bach Mine. Noranda,	Montréal Engineering Col. Ltd., Montréal Noranda Mines Ltd.	X	X		1973
Chapais, Abitibi-east, Opemiska Div.		X	X		1979
Iron Ore Co. of Canada Sept. Iles	N.B. Research and Productivity Council.	X			1974
Hilton Mines Ltd., Bristol.	Geography Department, Carleton University.	X	X		1974
ONTARIO					
Dome Mines Ltd., South Porcupine.	Montreal Engineering Co. Ltd. (CANMET) Erocon Ltd.	X	X	X	1969
Noranda Group of Co's (Parmour Porcupine Mines Ltd.)					
Parmour Mine	Montreal Engineering Co. Ltd. (CANMET).	X	X	X	1969
Schumachet Mine.	University of Guelph Crop Science Dept.	X	X		1973
Hallnot Mine	Mine Waste Reclamation Ltd., Guelph, Ontario	X	X	X	1969
Aunor Mine		X	X	X	1969
Preston Mines Ltd. (closed). Preston Mine.	Erocon Ltd.	X		X	1968
Agnico-Eagle Mines Ltd. Trout Lake Mine.		X		X	1972
Kerr Addison Mines Ltd. McGarry Twp; Virginatown Agnew lake	Mine Waste Reclamation Ltd., Guelph, Ontario	X	X		1969

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
ONTARIO					
Marmoraton Mining Co. Ltd. Marmora Mine.	Geography Department, Carleton University.	X			1970
Steep Rock Iron Mines Ltd. Steep Rock Lake.	Forestry Department, Lakehead University.	X	X		1978
Pickands, Mather & Co., Red Lake Griffith Mine.	Forestry Department, Lakehead University	X	X		1973
Chesterville Mines Ltd. Chesterville Mine.	Université de Sherbrooke, Centre de technologie de l'environnement.	X			1975
Omega Mines Ltd. Larder Lake, Omega Mine.	Université de Sherbrooke, Centre de technologie de l'environnement.	X			1975
Upper Canada Resource Ltd., Upper Canada Mine.	Université de Sherbrooke, Centre de technologie de l'environnement.	X			1975
International Nickel Co. Canada.					
Coppercliff	Laurentian University, Biology Department.	X	X	X	1939
Clarabelle	Ontario Environment.	X	X	X	
Frood-stobie	Montreal Engineering Co. Ltd. (CANMET).	X	X	X	
Shebandowan.	Ontario Ministry of Natural Resources.	X	X	X	
Falconbridge Nickel Mines Ltd.	Montréal Engineering Co. Ltd., Montréal (CANMET)				1964
E. Falconbridge Mine		X	X	X	
Onaping Mine	Biology Department, Laurentien University	X	X	X	
Hardy Mine		X	X	X	
Nickel Rim Mine	Erocon Ltd	X	X	X	
Conistan Mine.	University of Toronto.	X	X	X	
Denison Mines Ltd. Elliot Lake.	Mining Research Lab. Elliot Lake, Canada Centre for Mineral and Energy Technology. Erocon Ltd.	X	X	X	1976
Hollinger Consolidated Gold Mines. Timmins.	Erocon Ltd.	X	X	X	1935

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
ONTARIO					
Rio Algom Ltd., Elliot Lake.	Mining Research Lab. Elliot Lake, Canada				
Quirke Mine	Centre for Mineral and Energy Technology	X	X	X	1977
Nordic Mine		X	X	X	1971
Pronto Mine	Erocon Ltd.	X	X	X	1970
Oliver Lake Mine	H.Q. Golder and Associates. Canada	X	X	X	1977
Lancor Mine	Ministry of Environment, Industrial Waste Branch.	X	X	X	1978
Crotch Lake Mine.		X	X	X	1970
Teck Corporation, Silverfields Mine, Cobalt		X		X	1977
Noranda Mines ltd., GECO Division, Manitouwadge.	Crop Science Department University of Guelph. Mine Waste Reclamation Ltd., Guelph	X	X	X	1974
Texasgulf of Canada Ltd. Kidd Creek Mine, Timmins.	Montreal Engineering Co. Ltd. (CANMET). Erocon Ltd.	X		X	1966
MANITOBA					
Hudson Bay Mining and Smelting Co. Ltd. Flin Flon Mine.		X	X	X	1972
Sherritt Gordon Mines Ltd., Fox Mine, Lynn Lake	Crop Science Department, University of Guelph. Mine Waste Reclamation Ltd. Guelph.	X	X		1979
Ruttan Mine, Ruttan Lake	Noranda Mines Ltd.	X	X		1979

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
SASKATCHEWAN					
Manitoba and Saskatchewan Coal Company Ltd. Boundary Dam Mine, Estevan	Saskatchewan Power Corp. Soil Science Department, University of Saskatchewan.	X	X	X	1971
Bienfait Mine, Bienfait.	Forestry, Minstry of Natural Resources.	X	X	X	1966
Manalta Coal Ltd. Klimax Mine.	Soil Science Department, University of Saskatchewan University of Saskatchewan (CANMET). Forestry, Ministry of Natural Resources.	X	X		1968
Utility Coals Ltd. Utility Mine, Estevan.	Forestry, Ministry of Natural Resources. Canada Agriculture, Swift Current Research Station.	X	X	X	1971
Saskatchewan Power Corp. Souris Valley Coal Mine.	Soil Science Department, University of Saskatchewan (CANMET); Forestry, Ministry of Natural Resources: Canada Agriculture; Indian Head Tree Nursery.	X	X	X	1970
Saskatchewan Power Corp. Cornach, Poplar River Mine.	Soil Science Department, University of Saskatcewan Canadian Plains Research Centre.	X			1976
Eldorado Nuclear Ltd. Beaverlodge Mine	University of Toronto Inst. Environmental Affairs	X	X		1980

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
ALBERTA					
CanPac Minerals Ltd. - Fording Coal Ltd. Proposed new. Roundhill Coal Mine.	McAllister Environmental Services Ltd.	X	X		1975
Calgary Power: Manalta Coal Ltd.	McAllister, Environmental Services.				
Vesta Mine, Halkirk	Canadian Wildlife Service.	X	X	X	1975
Whitewood Mine, Wabamum	Alberta Environment, Land Conservation and Reclamation Division.	X	X	X	1963
Highvale Mine, Sundance.	Western Canada Erosion Control Ltd.	X	X	X	1970
Rosalyn Mine, Sheerness.	Alberta Agriculture, Soils Division	X	X	X	1974
Lake Wabamum	Vaartnou and Sons Enterprises Ltd. Montreal Engineering	X	X	X	1971
Camrose-Riley Project	Pedology Consultants				
Pit No. 2 and 3			X	X	1976
Trench Installation			X	X	1975
Fording Coal Ltd.	Pedology Consultants				
Camrose-Riley	Edmonton Power Ltd.	X	X		1975
Bow City — Kitsan	Western Soil and Environmental Consulting Services	X	X		1980
Shaughnessy		X	X	X	1980
Heatbury Power Project	McAllister Environmental Services Ltd.	X	X		1980
Genessee		X	X		1980
Coleman Colleries Ltd.	Alberta Environment Operational Planning. Energy and Natural Resources, Reforestation and Reclamation Branch.				
Tent Mountain Mine		X	X	X	1974
Vicary Creek Mine		X	X		1976
Racehorse Mine (closed)	University of Calgary.	X	X	X	1974
McIntyre Mines Ltd; Grand Cache, Smokey River Mine, No. 8.	Alberta Research Council, Soils Division. R. M. Hardy and Associates (CANMET).	X	X	X	1972

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
ALBERTA					
Cardinal River Coals Ltd., Hinton Cardinal River Mine.	Western Canada Erosion Control Ltd. Alberta Environment, Land Conservation and Reclamation Division. Environment Canada, Northern Forest Research Centre.	X	X	X	1969
Luscar Ltd., Forestburg Collieries Ltd. Diplomat Mine.	McAllister, Environmental Services Ltd. Pedology Consultants. Alberta Agriculture. Alberta Environment, Land Conservation and Reclamation Division.	X	X	X	1975
Canmore Mines Ltd., Canmore.		X	X	X	1971
Alberta Power Ltd.	Lussar Ltd.				
Battle River Recl. Project	Techman Ltd.		X	X	1979
Sheerness Test Pit			X	X	1979
Esso Resources Canada Ltd. Cold Lake Project	Hardy and Associates Manalta Coal Ltd. RRTAC	X	X		1980
Crowsnest Resources Ltd.	McAllister				
Blackfoot	Environmental Services Ltd.		X		1979
Pipestone			X		1978
Picardville				X	1978
Suncor Incorp. Oil (Great Canadian Oil Sands) Ft. McMurray	Alberta Energy and Natural Resources. Environment Canada, Northern Forest Research Centre. Norwest Soil Res. Ltd.	X	X	X	1970
Syncrude Canada Ltd. Ft. McMurray.	Thurber Consultants Norwest Soil Research Ltd. Engineering Consultants Ltd. Soil Science Forestry and Botany Departments, University of Alberta Alberta Agriculture. Vaartnou and Sons Enterprises Ltd. Oliver Provincial Tree Nursery. Alberta Forest Service.	X	X	X	1975

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
ALBERTA					
Alsands Ft. McMurray	Hardy and Associates	X			1980
BRITISH COLUMBIA					
Zapata Grandby Mining Corp. Granisle Copper Div. (Mine)		X	X		1971
Phoenix Copper Div. (Mine)	Interior Reforestation Co. Ltd.	X	X	X	1968
Craigmont Mines Ltd. Merrit.	Placer Development Ltd.	X	X	X	1969
Canex Placer Ltd., Fraser Lake.	Placer Development Ltd.				
Endako Mine.		X	X	X	1970
Canex Tungsten Mine.	Soil Science Department, University of British Columbia.	X	X	X	1970
Cassiar Asbestos Corp. Ltd. Asbestos		X	X	X	1977
Fording Coal Ltd. Elkford. Fording Mine.		X	X	X	1972
Coast Copper Co. Ltd., Port McNeil. Benson Lake	Cominco Co. Ltd. Soil Science Department, University of British Columbia (CANMET).	X	X	X	1970
Texada Mines Ltd. Gilles Bay.	Soil Science Department University of British Columbia (CANMET).	X			1974
Noranda Mines Ltd. Boss Mountain Division, Hendrix Lake.	Crop Science Department, University of Guelph.	X	X	X	1974
Bell Copper Mine, Babine lake.		X	X		1974
Afton Mines Ltd., Kamloops.		X			1976
Western Mines Ltd., Strathcona, Myra falls.		X		X	1972

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
BRITISH COLUMBIA					
Cominco Ltd.	Soil Science, University of British Columbia (CANMET)				
H.B. Mine. Salmo.		X	X		1971
Sullivan Mine, Kimberley.		X	X		1971
Pinchi Lake, Fort St. James.	Reclamation Division, Ministry of Petroleum Resources.	X	X	X	1970
Bluebell Mine, Riondel, Kootenay Lake.	B.C. Forest Service, Nelson	X	X	X	1976
Denison Coal Ltd.	B.C. Research				
Northeast Coal Block					
Quintette project		X	X		1977
Saxon project		X	X		1977
Sage Creek Coal Ltd.					
Sage Creek		X	X	X	1977
B.C. Coal Ltd. (Kaiser Resources Ltd.)					
Michel Colliery, Michel.	Forestry and Soil Science Departments, University of British Columbia.	X	X	X	1970
Harmer Ridge, Sparwood	R.M. Hardy and Associates (CANMET).	X	X	X	1970
McGillivray Mine (closed).		X	X	X	1970
Erickson Mine, (closed).	Fish and Wildlife Branch, Ministry of Mines anbd Petroleum Resources.	X	X	X	1970
Lower Mine (closed).	Biology Department, University of Victoria.	X	X	X	1970
Newmount Mines Ltd., Princeton. Similkameen Div.	Soil Science Department, University of British Columbia (CANMET).	X	X	X	1971
Gilbralter Mines Ltd. McCleese Lake.	Soil Science Department University of British Columbia (CANMET). Placer Development Ltd.	X	X	X	1970
Brenda Mines Ltd. Brenda Mine, Peachland.	Soil Science Department, University of British Columbia (CANMET).	X	X		1974
Lornex Mining Corp. Ltd. Highland Valley Mine.	British Columbia Research Council. Soil Science Department, University of British Columbia (CANMET).	X	X		1972

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
BRITISH COLUMBIA					
Bethlehem Copper Corp. Highland Valley Mine, Ashcraft.	Soil Science Department, University of British Columbia.	X	X	X	1972
Utah Mines Ltd. Island Copper Mines, Port Hardy.		X	X	X	1970
Carbon Creek Coal Property N.E. Coal Block	B.C. Research	X	X	X	1973
B.C. Hydro and Power Authority Hat Creek Coal Mine		X	X		1977
Byron Creek Colleries Ltd., Coal Mountain, Corbin		X	X		1977
YUKON AND N.W.T.					
Arctic Gold and Silver Mines Ltd. Carcross (closed).	Biology Department, University of Toronto. Department of Indian and Northern Affairs.	X	X		1976
Cominco Ltd. Con and Ryan Mines, Yellowknife.	Biology Department, University of Toronto. Department of Indian and Northern Affairs.	X	X		1972
Giant Yellowknife Mines Ltd. Yellowknife.	Geography Department, University of Alberta.	X	X	X	1979
Cypress Anvil Mining Corp. Faro.	Biology Department. University of Toronto. Department of Indian and Northern Affairs.	X	X		1976
Canada Tungsten Mining Corp. Tungsten.	Biology Department, University of Toronto. Department of Indian and Northern Affairs.	X			1976
United Keno Hill Mines Ltd. Elsa.	Biology Department, University of Toronto. Department of Indian and Northern Affairs.	X	X		1976

COMPANY: MINE SITE	COOPERATIVE AGENCY/CONSULTANT	EIA	FLD	RCL	APPROX. YEAR STARTED
YUKON AND N.W.T.					
Whitehorse Copper Mines Ltd. Little and Middle Chief Mines.	Biology Department, University of Toronto. Department of Indian and Northern Affairs.	X	X		1976
Venus Mines Ltd., Carcross.	Biology Department, University of Toronto. Department of Indian and Northern Affairs.	X	X		1976
Pine Point Mines Ltd., Pine Point.	Cominco Ltd. Biology Department, University of British Columbia.	X	X		1972

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